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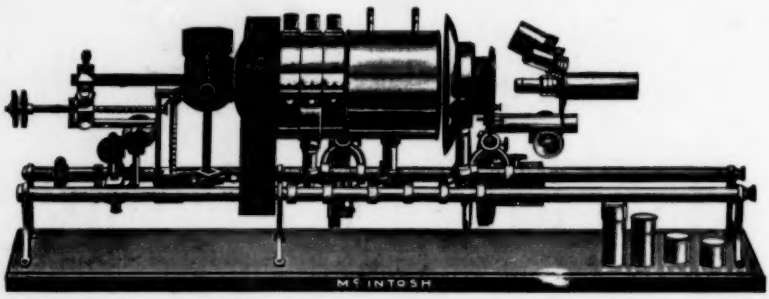

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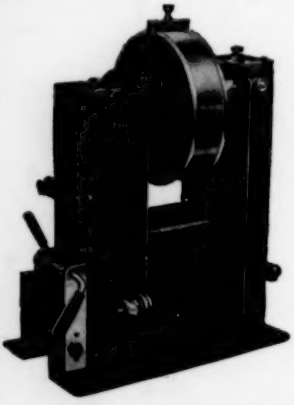

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SCHOOL SCIENCE AND MATHEMATICS

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THE MATHEMATICS OF COMMON THINGS.

BY HARRIET E. GLAZIER,

The Western College for Women, Oxford, Ohio.

The conception of what makes the scholar has changed greatly in these later years. In Geordie Howe of the *Bonnie Brier Bush,* we have pictured the pride of the little Scotch Kirk, taking every prize in Greek, Latin, and mathematics at the University of Edinburgh, a sort of intellectual prodigy, but going to an early grave from sheer lack of physical vigor; and in those days he was often considered the scholar who possessed a great fund of knowledge, combined with a small amount of common sense. So also was the early conception of the mathematician, one who could perform gigantic feats in the way of calculation, possessing, as Professor Carmichael says, "a sort of monstrosity of the human mind which has brought mathematics to the place it now occupies only because there has been an unbroken chain of men from the remote past up to the present who are characterized by an unusual development of that part of their mental organism in which such a monstrosity may appear."[1]

The idea of what constitutes scholarship has entirely changed until today we see the governor of our state, and the president of our nation, called to their high administrative offices from the ranks of the so-called scholars. Just so, the popular conception of the mathematician as a gigantic machine for making calculations, which idea perhaps never prevailed with the real mathematician, is fast changing with the world at large, until we have come to understand what our beloved Professor Maschke of the University of Chicago used often to say to the would-be mathematician, "Mathematics is the science of learning how *not* to compute."

[1]SCHOOL SCIENCE AND MATHEMATICS, Vol. XV, page 105.

To what was this false notion of mathematics due? Probably to this—a general lack of understanding and appreciation of what mathematics is, and whence and why it came. At the start, mathematics, like other sciences, has taken what nature has given, has interpreted, studied, and developed what it found, has given to the common concepts of size, form, and interdependence a universal language, and made it possible to formulate, systematize, and study these concepts according to law and order. Professor Moore has defined pure mathematics as "a language for the convenient expression and investigation of relations most diverse in ordinary life and in nature." Let us see how this sort of mathematics has developed in some of its elementary branches.

In Algebra.

From earliest times, it required no training of the schools to make the untaught savage understand that a half-dozen pebbles placed by a friendly chief at a certain spot in the forest would tell him how many of a hostile tribe were coming to wreak vengeance upon him. Nor hundreds of years later, among a civilized people, was there difficulty in understanding that the number of nails driven into a certain pillar, one each year, told how long it had stood. It is the same thing that we do today when votes are counted, we bring out the number concept by setting up a one-to-one correspondence between the objects counted and some representative group. The notion of number was before the science of mathematics. To formulate that notion of number and to extend it in such a way as to make it meet the need of an intelligent and civilized world, though never transgressing first principles, has been one of the missions of the algebraist.

This has not been an easy task nor one always understood. Fractional numbers seem not to have greatly disturbed the world; they were early accepted, though the treatment of fractions presents one of the most interesting chapters in the history of elementary mathematics. But the irrational number appearing in the simple surd, $\sqrt{2}$, which they found was the inevitable result of attempting to measure the diagonal of a square with a unit common to the side, turned the Greeks away from algebra and left them a people to develop demonstrational geometry even as it is today.

The negative number, too, was meaningless until a few centuries ago, not to the untaught alone, but even to the so-called mathematicians, if we may judge from the way they were char-

acterized by Descartes as late as the seventeenth century by the term, *numeri ficti.*

But the irrational and negative numbers were not half so formidable as another, the last perhaps to be received into full citizenship in the number world. I refer, of course, to the imaginary. That its relationship to the rest of the number family remains still a mystery to many, who count it an alien in spite of books and teachers, is but painfully evidenced in the case of many students, and the freshman is not rare who tells you in all seriousness that an imaginary number is a "feat of the imagination." In testimony of my feeling that this whole subject of number, one of the richest and choicest fields of mathematics, is still nothing short of a puzzle to half our students, I should like to cite the answers received a few years ago to the following question: Given the binomial expansion $(a+b)^k = a^k+ka^{k-1}b+\frac{k(k-1)}{1\cdot 2}a^{k-2}b^2+\cdots\cdots$. What kind of a number for k will make the series finite? The following reply is perhaps the most marvelous: "This series is finite when it has a finite number as exponent, and infinite when it has not. K may stand for anything and go on forever." Among the other varying replies, the necessary k was described as known, unknown, positive integral, rational, negative integer, a definite fixed number, a whole number, positive and its value known, negative and fractional, finite, and infinite. Fancy the mental condition on the part of students behind such statements! How different is all this from the simple interpretation of real numbers by lengths on a directed line, and the representation of the imaginary by means of vectors.

Quality.—Take again the notion of quality as associated with numbers. Perhaps the truest testimony that the negative number came to fill a real need is through its interpretation of the notion of quality. And since this notion of quality belongs to all kinds of numbers, it deserves consideration as an independent mathematical concept. The world is filled with objects, history with events, our mental machinery with notions, which stand in contrast or opposition to each other. Some of the most common of these are discussed in every elementary algebra. Distance east is set over against distance west; temperature above zero against temperature below; surplus is contrasted with debt; an event after the great European War with one before. This idea of oppositeness is everywhere present. It was found as

early as the fifteenth and sixteenth centuries when the Italian merchant marked the keg of deficient weight with the sign —, and of surplus weight with the sign +. It is found today in the character of the man who exerts a positive or negative influence, as the case may be, upon his day and generation.

True it is, that the real meaning of the quality concept is too often concealed in the cloak of mathematical symbolism, or lost in the rules for solving problems, supposed to constitute mathematics, but which are no more mathematics than music is the striking of certain keys in certain stated order. And to many a student, the algebraic positive and negative, or more simply the signs of quality + and —, although having complete and universal acceptance and interpretation, present more difficulty than any other one thing in algebra, and yet they are symbols subject to uniform interpretation throughout all mathematics and that an interpretation of one of the most common of all natural conditions, oppositeness.

Conditional Equations.—Again, problems arose demanding certain number values to meet certain conditions. It may have been in mechanics—it may have been in astronomy—or it may have been something in mathematics itself, like the necessity of finding the mean proportional between one straight line, a, and another twice as long, $2a$, in the famous problem of duplicating the cube. This condition was formulated in the language of algebra, and to the mathematician came the conditional equation, with an almost unlimited field for the study of the number and character of the solutions possible to meet the given conditions. It did not come fully developed, or as we have it today, but it took its present form slowly. The Egyptians wrote the linear equation, "heap, its seventh, its whole, it makes nineteen." Diophantus, early in the fourth century, introduced a syncopated form for writing the equation which has been gradually improved until today we say with no thought of question, $x + \frac{x}{7} = 19$.

Function.—One other mathematical notion, and we will leave the algebra for a little. This is the notion of dependence of one thing upon another, to be found everywhere. There is an old saying, "All is change, nothing is permanent." The physician studying the nature of his patient's disease must be cognizant of the change from hour to hour; the popularity of a certain textbook is a matter of concern to the publisher, and an investigation is made of its yearly sales; it is important to know the value of

our farm products, and a study is made of the wheat yield for a certain period of time. Mathematically, we say of all this, the temperature of the patient is a function of the time, the sales of the book, or the yield of the wheat, vary with the years. Or, in the study of natural law, we find the weight of an object changes as it nears the earth and depends upon its distance; the speed of a chemical reaction depends upon varying physical conditions, while in the study of certain geometric figures, we find the area varying as the square, and the volume as the cube of a single linear dimension. Professor Hederick even goes so far as to question whether there is any one quantity in nature, or in science not invented by man, which is fixed, unchangeable, whose qualities and properties suffer no alteration. And he holds that this is indeed "the chief direct value of algebra . . . . . the study of variable quantities, the relations between such variable quantities, and the acquisition of the ability to control and to interpret such relations."[2] The study of the functional relation has, as everyone knows, a large place in our present-day mathematics, and perhaps makes the strongest appeal to the popular mind. The graph, recording as it does in its simplest form the changes in each of two related things by means of a single curve, has been taken up in every line of study, and the frequency of its appearance is the strongest testimony to its general application and usefulness.

Again, we cannot leave this mention of the graph without turning for a moment to certain other natural phenomena and conditions. A cannon ball shot out into the air makes a path which is absolutely continuous. Compute its distance traveled for consecutive periods of time, and between any two values so determined will be an infinite number of numbers which would each represent, in turn, the distance traveled for periods of time between those first considered. In mathematics, we say numbers are discontinuous quantities. In nature, we say numbers are continuous. But just here has come the graph with its seemingly continuous curve and the calculus with its study of the variable through an infinitesimally small increment of change, and again nature and mathematics go hand in hand.

GEOMETRY.

Now let us turn away from the common algebraic notions of number, quality, the equation, and the function, and look at what

[2]SCHOOL SCIENCE AND MATHEMATICS, Vol XI, page 54.

we have in geometry. Again mathematics, like other sciences, goes to nature for the things it observes and studies. The settler tethers his cow to a stake, and he needs no learning of the schools to convince him that the cow can graze on every bit of grass which is not farther from the stake than the length of the rope. The cow knows it, too, and quietly stretches the rope to its fullest length, and the straight line of the rope and the circle of grazing land are complete and perfect.

In an adjoining field, two summers ago, a spirited colt was tethered to a post to feed in the meadow. Satisfied with feeding, and longing to be free, hundreds of times each day she would straighten the leash, and take the circle, the graceful bend of the body seeming almost to belong to the curve of the path. It would be hard to find a circle marked out with greater fineness of precision by any compass of man's make. And here comes the marvel of it all. From these simple figures, aided by formal logic, there has developed an elementary geometry of the straight line and circle, wonderful in its simplicity and its possibilities.

The other day we had crackers with our soup, and it was interesting to see that the manufacturer had discovered what the Greeks knew long ago, that the space about a point in a plane is entirely filled by three regular hexagons. The Greeks and Romans used this knowledge of the regular hexagon in the tilings of their floors, as well as similar combinations of rectangles and triangles. But this modern cracker manufacturer has discovered that there is absolutely no waste, combined with pleasing symmetry of form, if the material is marked with the hexagonal cutter. One begins to understand why our mothers cut the toothsome and much-sought-for gingerbread into "cards" instead of circles.

It is said that certain properties of simple, straight line figures, one of them the triangle, were early observed; but by means of the systematic and scientific study of geometry, an almost innumerable number of strangely beautiful properties of the triangle have been found, with its incenter, its excenters, its orthocenter, its circumcenter, its center of gravity, the collinearity of centers, the nine-point circle, and all the rest, until Crelle, himself one of the foremost investigators of it, exclaimed: "It is indeed wonderful that so simple a figure as the triangle is so inexhaustible in properties. How many as yet unknown properties of other figures may there not be!"

How the practical side of geometry has been inseparably as-

sociated with human affairs is perhaps as wonderfully illustrated by the Pythagorean theorem as by any other one thing. Hundreds of years before Christ, used by the Egyptians in the orientation of their temples (when the sides of the triangle were as 3 : 4 : 5) ; observed by the Greeks in the tilings of the floors; claimed to have been known by the Chinese and Japanese long before the Christian Era; receiving its first general proof from Pythagoras; recognized by the Hindoo Bhaskara in the twelfth century, the proof consisting only of a simple figure and the word "Behold," it is the statement of a fact so simple that the veriest school boy smiles to think that anyone ever questioned it, and yet so wonderful that it has held the interest of soldiers and statesmen to devise new and varied proofs of it.

How utility brings us back to the simple forms! Following nature, we, too, have adopted the straight line and circle in architecture and building until one is amazed at the marvelous combinations of the straight line and circle that have lent themselves to practical use. One need only mention the universal straight line of the building, combined with the various forms of arches, celebrated both for beauty and utility, and with hardly an exception employing the circle in their construction. Note the semicircular arch of the Romans and the famous Gothic and Moorish arches of a later day. That these simple forms even yet quite satisfy our sense of beauty has been evidenced in the mission style of the buildings of the great Panama-Pacific Exposition just closed in California.

But enough. What of the why and the whence of mathematics? It has simply taken what nature has given for study and investigation, the commonest concepts of size, form, number, and the interdependence of one thing upon another. It has given these concepts a universal language and made it possible to study them according to law and order. It did not need the botanist to tell the tree trunk that the circular arrangement is best for its growth, nor the flower to gather its petals about the centre. It was not the scientist who taught the bird how to make her nest or rear her young, nor the mathematician with his calculus that led the bees to construct the hexagonal cell for storing their honey. All these things existed without the worldly wisdom of books. But the facts of their existence are of interest to one who thinks and wishes to know.

And now some one asks: "What place has this sort of mathematics in any system of education for boys and girls?" I should

like to quote the definition of an educated man, recently given to a body of university students, as "one possessing an interested and an interesting mind." Is there not much we should expect from the subject of mathematics, interpreting as it does through its algebra so many natural conditions everywhere existing in number, quality, and functional relations, and giving to all students a universal language for expressing and studying these conditions and relations, while it gathers up in its geometry the accumulated wealth of hundreds of generations who have seen and appreciated the beauty, and interpreted and studied the significance of simple geometric form?

In a world so full of interesting things with the infinite variety of number, form, and size, how can one be truly educated who fails to see what these have to contribute?

SOME THEOREMS FROM PAPPUS ON ISOPERIMETRIC FIGURES.

By James H. Weaver,
West Chester, Pa.

Ever since the time when the idea of greater than or less than entered the mind of man, he has been concerned with the notion of maximum or minimum values of lines, areas, volumes, and functions that satisfy certain given conditions. One phase of this question that was early developed among the Greeks is that of isoperimetric figures, that is, a comparison of figures, both plane and solid, that have equal perimeters or equal surfaces The first treatise written on the subject was that of Zenodorus, an Alexandrian who flourished sometime during the second century B. C. Fourteen of the theorems of Zenodorus have been preserved by Theon of Alexandria. (For the theorems and their proofs, see *Pappus Alexandrinus, Collectio,* Hultsch, Berlin, 1876-8, pages 1189 and ff.) These same theorems have been recorded by Pappus who gives several others, some of which may be original. (See Hultsch, Book V.) One series of lemmas given by Pappus is of special interest because it sets up the comparison of several peculiar kinds of plane figures and gives a glimpse into the ingenuity of the Greek mind.

The proposition to be proved finally is: "Of all areas included by an arc of a circle of given length and its chord, the greatest is a semicircle." The discussion is as follows (See Hultsch, pages 340 and ff):

Lemma I. Similar segments of circles are to each other as the squares on their chords.

Let there be two similar segments ABC and DEZ (Figure 1) with their chords AC and DZ, then segment ABC : segment DEZ = $AC^2 : DZ^2$.

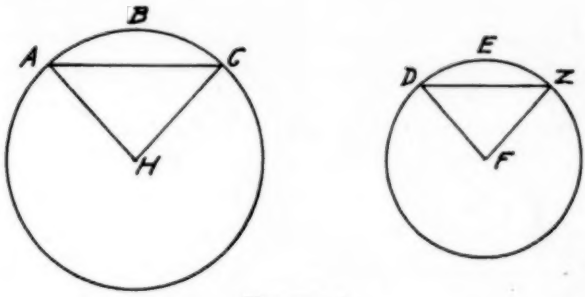

FIGURE 1.

Let the circles be completed and let their centers be H and F, and let AH, HC, DF, and FZ be drawn. Now, because the segments ABC and DEZ are similar, the angles H and F are equal and the triangles AHC and DFZ are similar.

Therefore,

circle ABC : sector AHCB = circumference of circle ABC : arc ABC
= four right angles : $\angle$ H,

and

circle DEZ : sector DFZE = circumference of circle DEZ : arc DEZ
= four right angles : $\angle$ F.

Therefore,

circle ABC : sector AHCB = circle DEZ : sector DFZE,

and by alternation,

circle ABC : circle DEZ = sector AHCB : sector DFZE.

But

circle ABC : circle DEZ = $AH^2 : DF^2$ = triangle AHC : triangle DFZ.

Therefore,

sector AHCB : sector DEFZ = triangle AHC : triangle DFZ,

and since the difference of the antecedents : difference of consequents, any antecedent : its consequent,

segment ABC : segment DEZ = triangle AHC : triangle DFZ.

Therefore,

segment ABC : segment DEZ = $AC^2 : ZD^2$.

(In this connection Pappus also proves that arc ABC : arc DEZ = AC : DZ. This proof is so simple that I will omit it here.)

Lemma II. Let there be two circles and at the centers of these circles let there be the equal angles ABC and DEZ (Figure 2). Also let there be drawn the tangents AH and DF, which intersect the lines BC and EZ produced in H and F respectively, and let AK and DL be drawn perpendicular to BC and EZ respectively.

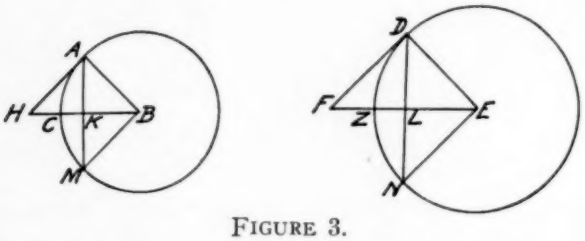

FIGURE 3.

Then, triangle AHK : three-line ACK = triangle DFL : three-line DZL (the term three-line as used here means a plane figure bounded by straight lines and arcs of circles).

This is evident from Lemma I. For the triangle AHK is similar to the triangle DFL and the three-line ACK to the three-line DZL (if DL and AK are produced to N and M respectively, where N and M are points of the circles, then the segments ACMK and DZNL are similar, and consequently their halves are similar and

triangle AHK : triangle DFL = AK^2 : DL^2 = three-line ACK : three-line DZL.

Lemma III. Let there be a right triangle ABC, having B as right angle, and with C as a center through A describe the arc AD cutting CB produced in D.

Then,

sector DCA : three-line DAB > right angle : $\angle$ BCA (Fig. 3).

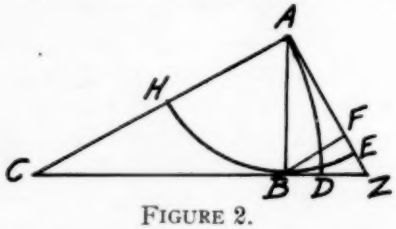

FIGURE 2.

Let ZA be drawn perpendicular to AC and cutting CB produced in Z (AZ is therefore tangent to the arc AD), and with A as a

center let there be described through B the arc HBE cutting AC in H and AZ in E, and let BF be drawn perpendicular to AZ.

Now,

three-line EBZ : three-line EBF > three-line EBZ : sector EAB.

By composition,

triangle FBZ : three-line EBF > triangle ABZ : sector EAB, and
triangle FBZ : three-line EBF = triangle ABZ : three-line DAB
(Lemma II, because the angles EAB and DCA are equal).

Therefore,

triangle ABZ : three-line DAB > triangle ABZ : sector EAB.

Consequently,

sector EAB > three-line DAB.

Therefore,

sector EAB : sector BAH > three-line DAB : sector BAH.

But,

three-line DAB : sector BAH > three-line DAB : triangle BAC.

Therefore,

sector EAB : sector BAH > three-line DAB : triangle BAC.

But,

sector EAB : sector BAH = $\angle$ZAB : $\angle$BAC.

Therefore,

$\angle$ZAB : $\angle$BAC > three-line DAB : triangle BAC.

By inversion,

triangle ABC : three-line DAB > $\angle$BAC : $\angle$ZAB,

and by composition,

sector DCA : three-line DAB > $\angle$ZAC : $\angle$ZAB
> right angle : $\angle$BCA.

For $\angle$ZAB = $\angle$ZCA, because of the similar triangles ZAB and ZCA.

Lemma IV. Again let there be a right triangle ABC with the right angle at B, and with C as center through A let the arc AD be described, cutting BC produced in D.

Then (Fig. 4),

sector ACD : three-line ABD > right angle : $\angle$ACD.

Let AE be drawn perpendicular to AC and let AB be produced, and through C with A as center let the arc ECZ be drawn, cutting AB produced in Z. Now it is clear that the two arcs AD and ECZ are equal, because they have equal radii. And $\angle$ACD > right angle ABC, that is, > $\angle$CAE. Therefore, the sector ACD > sector CAE.

Therefore,

sector ACD : triangle ABC > sector CAE : triangle ABC, and

> sector CAE : sector CAZ.

But,

sector CAE : sector CAZ = ∠CAE : ∠CAZ.

Therefore,

sector ACD : triangle ABC > ∠CAE : ∠CAZ.

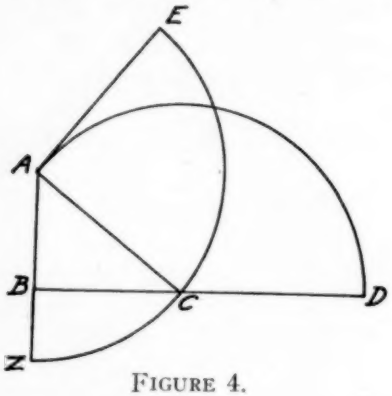

FIGURE 4.

By inversion and composition,

sector ACD : three-line ABD > ∠CAE : ∠ZAE, that is,
> right angle : ∠ACD,

because ∠ZAE = ∠ACD, each being a right angle plus the angle BAC.

Theorem. Of all areas included by an arc of a circle and its chord, the greatest is a semicircle.

1. Let there be two segments of circles ABC and ZED, and let the arcs ABC and DEZ be equal, and let ABC be a semicircle and DEZ a segment less than a semicircle, then ABC is greater than DEZ.

Let the centers of the circles (Figure 5) be H and F, and let the perpendiculars HB and FKE be drawn, and the diameter LM parallel to DZ and the radius DF be drawn.

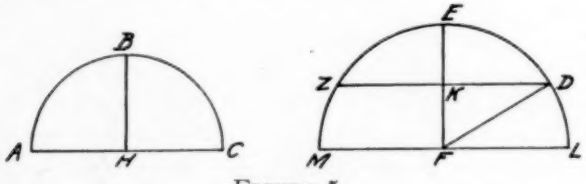

FIGURE 5.

Now,

arc LE : arc AB = radius LF : radius AH,
and arc AB = arc DE.

Therefore,

arc LE : arc DE = LF : AH,
= sector LFE : sector DFE.

But,

$LF^2 : AH^2 = LF : X$ (where X is defined by the proportion LF : AH = AH : X),

and,

$LF^2 : AH^2$ = sector LFE : sector AHB,

and,

LF : AH = sector LFE : sector DFE.

Therefore,

sector LFE : sector DFE = sector DFE : sector AHB, and on account of Lemma III,

sector DFE : three-line DEK > right angle : $\angle$ DFE, that is,
> $\angle$ LFE : $\angle$ DFE,
> sector LFE : sector DFE.

And

sector LFE : sector DFE = sector DFE : sector AHB.

Therefore,

sector DFE : three-line DEK > sector DFE : sector AHB.

Consequently,

sector AHB > three-line DEK, and

semicircle ABC > segment DEZ.

2. The proof for this part when DEZ is greater than a semicircle is exactly the same as the proof given above with the exception that Lemma IV is used instead of Lemma III. This proof will be left as an exercise for the reader.

DEFINITIONS IN GEOMETRY.

By Robert R. Goff,
Fall River, Mass.

A regular polyhedron has among other properties all its faces congruent polygons. Now a regular prism which is a polyhedron, is usually defined as a right prism whose base is a regular polygon, nothing being said about the lateral faces. This is inconsistent of course. A prism can have a regular base or regular faces, but in neither case is it necessarily a regular prism. The only regular prism possible is the cube.

The definition of a regular pyramid, which is a polyhedron, does not require the lateral faces to be congruent to the base. A pyramid can have a regular base or regular lateral faces but in

neither case is it necessarily a regular pyramid. The only regular pyramid possible is the tetrahedron.

The definition of circular cylinder makes no mention of the right section. As a circular stovepipe is one whose right section is a circle, it seems reasonable to expect a circular cylinder to be one whose right section is a circle. Also a circular cone should be one whose right section is a circle.

A segment of a sphere is that part of the sphere between two parallel planes. Then a segment of a circle might be that part of the circle between two parallel lines.

A median of a trapezoid is the straight line joining the middle points of the non-parallel sides. Then a median of a triangle might be the straight line joining the middle points of the non-parallel sides.

Now, I fully realize that it is unwise to bring in new terms unless a need for these terms is clearly shown. Nevertheless, I suggest the following definitions:

A so-called regular prism is a right prism with regular base.

A so-called regular pyramid is a right pyramid with regular base.

A so-called circular cylinder is a cylinder with circular base.

A so-called circular cone is a cone with circular base.

A circular cylinder is a cylinder whose right section is a circle.

A circular cone is a cone whose right section is a circle.

A segment of a circle is that part of the circle between two parallel lines.

The mid-line of a triangle or trapezoid is the straight line joining the middle points of two non-parallel sides.

Two lines that do not meet are not necessarily parallel; and a line and a circle are not necessarily tangent if they touch at one and only one point. The words "in the same plane" belong in the second definition just as much as in the first.

[At the suggestion of the author, this is published with the object of inviting criticism. In addition to the definitions noted, are there not others that need revision? During the years 1908 and 1909, in several articles published in this journal, G. W. Greenwood gave excellent discussions of the definitions of an angle, a limit, congruent figures, equal figures, and a prism. He showed that a solid can be constructed, satisfying the definition of a prism usually given in geometries, which is not a prism. Textbooks in geometry published recently contain this false definition of a prism and a false definition of a prismatoid.—MATHEMATICS EDITOR.]

AN EXPERIMENT, "RELATIVE VALUE OF COMMERCIAL AMMONIA WATERS BY TITRATION (NEUTRALIZATION)" WITH COMMENTS APROPOS.

By Earl Eastman,
Atlantic City, N. J., High School.

We had last year an experiment on "Percentage Strength of Commercial Ammonia Waters," suggested by an article in School Science and Mathematics, Vol. XIV, No. 2, page 169, by H. R. Smith. We decided this year to rewrite the experiment since the value of ammonia water depends primarily on three factors, viz.:

1. Price paid.
2. Percentage strength.
3. Total volume bought.

The special advantages that an experiment of this type possesses seem to us:

1. In general, an interesting, practical, approximate application of the law of definite proportions, as illustrated in the study of neutralization as a quantitative act.

2. Specifically:

(a) Cochineal rather than methyl orange as indicator, making "end point" clearer both by artificial light and by sunlight.

(b) A "step-up" preliminary titration of the sample of ammonia water with the normal acid to determine approximately the number of cc. of the acid to be used in part (b) which procedure also familiarizes the pupil with the use of the burette.

(c) Having ready with contained indicator just a little less than the correct volume of normal acid solution, and discharging into it the ammonia water to be accurately titrated, so that there is quick neutralization, little opportunity for ammonia gas to escape, and only a small range to be titrated through, drop by drop.

Some Interesting Notes on Actual Working Out of Experiment.

(a) It might be interesting to note that while 79.39 cc. N/1 acid (average of eight trials) were required to titrate 10 cc. of a given sample by above procedure, 65.11 cc. (average three trials) were required after the ammonia water had been exposed five minutes, and only .30 cc. (average two trials) were required after twenty-four hours' exposure.

of three hours, to do and write up this experiment. The time will be doubtless shortened in the future by instructor's study of devices, arrangement, and the providing of more suitable equipment, e. g., more 10 cc. bulb pipettes, etc.

(c) A sheet summarizing the results of about fifty students' analyses is appended. This was pasted in the notebook, discussion and conclusions thereon made.

(d) The "whole business" may be only "making motions," or "monkey work" unless the thing is properly discussed, and the reasons for the various procedures noted, likewise the limitations.

Neutralization—Titration—Value of Commercial Ammonia Water.

Object:

1. *Class as a whole.* To find the best brand of ammonia water obtainable for a given outlay, by means of titration applied to neutralization.

2. *Individually.* (a) To find approximately the number of cc. of normal hydrochloric acid solution (N/1 HCl+Aq) that will be required to neutralize 10 cc. of the given sample of ammonia water. (b) To make five accurate titrations of the ammonia water, and average the results. (c) To compute the per cent by weight of ammonia gas present. (d) To measure the volume of ammonia water bought, and then compute the total weight of ammonia gas secured for the price paid. (e) To compute the cost per gram and per 100 grams.

General Cautions. Exercise the utmost cleanliness and care. Do not leave cork out of the ammonia bottle. Why? Try to read the nearest tenth of a scale division.

Procedure, Observations, and Immediate Conclusions: (a) With a sharp file scratch the level of the ammonia water within on the outside of neck of the bottle. Open the bottle, trying to take out cork whole, or nearly so. Replace cork. Fill the thoroughly clean burette 2 or 3 cm. above the zero mark with the normal acid solution supplied by the instructor. Allow the acid to flow out drop by drop into some receptacle until the bottom of the liquid curve (meniscus) is just opposite the 0 mark. This gives practice in the "feel" of the burette stopcock so that you may have complete control of it later in the experiment. What other reason for not filling the burette just to the 0 mark?

Take the small (75 cc.) flask, add 5 or 6 drops of the indicator (cochineal) solution, then 25 cc. approximately of water,

then 1.00 cc. of the ammonia water with a graduated pipette as demonstrated. Note that the color is violet (some call it purple), after gentle agitation. Now run in 1.00 cc. of acid from the burette.[1] Agitate gently yet thoroughly. If the color does not change to a yellowish-red, run in another 1.00 cc. of the acid, and so on, stopping as soon as you get for the first time the yellowish-red color. Record:

Reading of burette when purple was last seen—.....

Reading when yellowish-red color first appeared—.....

The indication is that at least how many cc. of the acid will be required in (b) where 10 cc. of the ammonia water will be thus neutralized?

Wash the flask thoroughly, and repeat the preceding except that between the limits found above, run in the acid, 0.1 cc. at a time. Record:

Reading of burette when purple color was last seen—.....

Reading of burette when yellowish-red color first appears—

.....

(b)

Trial	Acid Burette Reading At End	At First	Ccm. N/1 HCl+Aq Used.
1	.....	.....	.....
2	.....	.....	.....
3	.....	.....	.....
4	.....	.....	.....
5	.....	.....	.....
Average	.....		.....

Suppose 2.60 of the acid were used in the last of (a). Take .10 cc. less, multiply by 10 (giving 25.0 cc.). Record in table above the present acid burette reading. Run the number of cc. of the acid solution thus obtained into a small (75 or 100 cc.) beaker. Add 10 drops of the indicator solution. Then with the graduated pipette, run in very accurately 10.00 cc. of the ammonia water, holding end of pipette just above the liq. surface. (Recork bottle.) Gently but thoroughly stir with small glass rod. The color will be purple if the work has been accurately done. Now run in the acid from the burette drop by drop, stirring thoroughly each time, until one drop causes the appearance of the yellowish-red color, i. e., until the "end point" is reached. Record burette reading in table above, under "at end." Write the equation for the chemical change.

[1] If pipette is provided with a rubber tube 6-12 inches long, there is (a) better control of flow and (b) less possibility of liquid getting in mouth.

Suppose 25.65 cc. of the normal acid is used. Repeat the above with all necessary precautions, but notice that this time you may doubtless run 25.40 cc. of acid into beaker, thus giving a less range to go through drop by drop. Tabulate, etc., as above.

Repeat the above three more times until you have five accurate titrations. Complete table.

(c) Compute as indicated:

$$\frac{\text{Average cc. of N/1 acid used}}{\text{Volume ammonia water}} = \text{Normality of ammonia water.}$$

$$\frac{???.??}{10.00} = ??.??$$

$$\frac{\text{Normality of ammonia water}}{\text{Normality 1\% ammonia water}} = \text{Per cent of ammonia gas by weight in sample.}$$

$$\frac{??.??}{.588} = ??.?? \quad \text{(Show division in full.)}$$

$$\text{Grams of } NH_3 \text{ in 1 l of N/1 am.} \underset{16.93}{\text{Aq}} \times \underset{??.??}{\text{Normality of sample}} = \underset{??.????}{\text{Grams per liter in the sample.}}$$

(d) Quickly pour out the ammonia water left in your original bottle into some suitable receptacle, which cover at once. Fill your bottle with water to the mark denoting the original liquid level. Pour out all this into a 500 or 1,000 cc. graduate (as seems necessary from the volume of your bottle). Use the smallest graduate possible. (Why?) Record the number of cc. thus obtained. Shake out all the water possible from the ammonia bottle, and pour back in the original ammonia water if you wish. Compute:

$$\underset{.????}{\text{Dec. of a lit. bought}} : \underset{1.000}{\text{1 lit.}} = \underset{x}{\text{grams bought}} : \underset{??.????}{\text{grams per lit.}} \quad \text{(see above).}$$

(e) Enter your results as the first in the table below. Results of other pupils will be summarized and entered later. Show just below this line in full the computation that gives you the last two items of yours.

Date 1916.	Brand.	Total Volume Ammonia Water.	Paid for this Vol.	As Regards the Valuable Constituent Ammonia Gas, NH_3. Total Grams.	Per Cent by Wt.	Cost. 1 Gram.	Cost. 100 Grams
John Brown	Johnson's	508cc.	11¢	24.24	4.81	$0.004538	45.38c

Brand.	No. Samples Analyzed	Ave. Total Volume Liquid	Ave. Price Paid (Cts.)	As Regards the Valuable Constituent, Ammonia Gas Total Grams	Per Cent by Wght.	Cost per 100 Gm. (Cts.)
Acme	5	358	4.2	8.90	2.50	46.56
Atlantic & Pacific Extra Strong	1	464	5	23.57	5.10	21.21
Childs', Century	5	328	8.7	17.50	5.37	49.62

Childs', Imperial	4	323	5	10.01	3.11	50.07
Clawson's	1	365	10	31.53	6.67	31.71
Climax	7	427	5	14.42	3.43	35.49
Colburn's	1	485	10	43.28	8.96	23.11
Defender	1	530	10	17.04	3.23	58.60
Dunlap's Best XXX	3	952	10	18.05	1.89	53.86
Dunlap's Champion	1	357	5	7.49	2.11	66.76
Empress	1	271	5	8.15	3.02	62.56
Frick's 905	1	305	10	42.16	13.88	23.72
Gordon's Special	1	270	10	24.95	9.28	40.06
O. K.	2	449	5	8.91	1.99	56.20
Our Special	1	278	10	20.71	7.48	48.29
Parson's Household	1	316	10	36.81	11.70	27.17
Stebbins' White Foam	1	293	5	28.78	9.86	17.38
Valley	3	387	5	15.20	3.95	33.10
Wild Rose	1	350	5	10.55	3.03	47.37
Local Pharmacies:						
Apollo	1	251	10	17.34	6.94	57.68
Galbreath	1	320	10	50.06	15.71	19.98
Park	2	207	10	14.54	7.07	71.42
Smith and Beck	1	243	5	23.12	9.56	21.63
Wright's Pharmacy	2	108	10	12.43	11.11	96.58

AMERICAN MINERAL WAX.

The American need for ozokerite (a substance commonly known as mineral wax) has heretofore been largely met by imports from the mines in Galicia, Austria, but as the war in Europe has seriously affected ocean transportation, interest in the domestic supply of this material has been stimulated. In order to obtain information regarding the deposits of ozokerite in Utah, the principal deposits in this country, a geologist of the U. S. Geological Survey, Department of the Interior, examined, in September, 1914, the deposits near Soldier Summit and Colton, in the central part of the state.

As described in the resulting report by H. M. Robinson, the ozokerite is found in fissures and brecciated zones, principally in the Wasatch formation, of Eocene age. Tests made by the Bureau of Mines on six samples show their specific gravity, solubility, melting point, and the fractional distillates they yield, and it is suggested that by boiling crude ozokerite with strong denatured alcohol a commercial separation of the refined product ceresin may be made. On account of the irregular distribution of the ozokerite no safe estimate can be made as to the quantity of undeveloped ozokerite, but the quality, as far as the melting point is concerned, compares favorably with the Austrian product, and the market conditions brought about by the war in Europe offer exceptional opportunities for the development of Utah ozokerite.

Ozokerite is a nonconductor of electricity and is extensively used for insulating. Candles made from ozokerite have superior qualities. Much of the ozokerite mined is converted into ceresin, a highly purified product which is used to replace or mix with beeswax and has a variety of other uses. Ozokerite is also used as a foundation for various waxes and polishes, as a covering to protect metal surfaces from the action of moisture, acids or alkalies; and for wax figures and dolls.

A copy of the report—*Bulletin 641-A*—may be obtained free on application to the Director of the Geological Survey, Washington, D. C.

PROJECT SCIENCE, PROGRESSIVE.

By J. C. Moore,
Bridgeport, Conn.

That the results of physics teaching do not measure up to reasonable expectancy, that they are lacking in returns when checked by modern ideas of present-day efficiency, must be admitted by all fair-minded people. The physics teacher has too long followed tradition, been satisfied with academic standards and academic ideals.

During the past decade, the kindergarten and primary grades have been subject to close scrutiny, and have profited by a study of methods, so that today we find some of the best teaching in these grades. With the increase in the number of secondary school graduates, the public will demand a reform in secondary school methods. Michael Sadler wrote on the "Unrest in Secondary School Education," but there never was a time when the public at large were so keenly alive to the problem of education in America, and demanding returns.

It behooves the science teachers of the state to be open-minded, unprejudiced, ready to cooperate, to originate and test improved methods for our common cause. The criticism is not scattering, it is becoming massed. The science of the average man is learned after school, not in school, and he freely admits that he has forgotten most of the physics taken in school. Where does the lawyer, doctor, or merchant learn in regard to the automobile, the relative merits of starters, grades of gasoline, types of office lighting, and the thousand other questions or projects that arise in daily life?

The Government, through its agricultural bulletins, manufacturing concerns, through well-illustrated pamphlets written in nontechnical language and numberless industrial catalogs, is supplying the knowledge sought by the people, and sadly lacking in our textbooks.

"Notwithstanding the increased importance of science as a factor in modern life, it is a fact well known to students of education that the percentage of students studying the older sciences in our public schools is on the decline, and has been on the decline for twenty years." In commenting upon the tendencies in our high schools, the Commissioner of Education says, "Latin is holding its ground; French and German are gaining; algebra occupies a large share of time and is steady; English and history

have gained materially; all the older sciences, rather strangely, are relatively falling off."[1]

In a recent study of science teaching in Missouri, science lost 15.2 per cent in its percentage enrollment in nine years. The average high school student often elects but one course in specialized science, which gives him an extremely narrow outlook upon the world about him, and a very inadequate basis for future scientific study. The report continues, "The general public are at last aroused to the fact that they have a right to demand practical, usable education for the great majority, rather than special training for the few who may desire to enter college."[2]

In a study of the preferences of pupils of Decatur, Dubuque, and Hagensack, only nine per cent of the girls taking physics considered it most useful, while forty-six per cent considered it least useful. They ranked as most useful: English, fifty-nine per cent; typewriting, forty per cent; arithmetic, thirty-eight per cent; bookkeeping, thirty-two per cent; domestic science, thirty-one per cent; Latin, sixteen per cent; civics, 9.4 per cent; physics, nine per cent.[3]

In New York state, forty-eight per cent of high school pupils are in the first-year class. We manage to eliminate more than one-third of these, so that twenty-six per cent appear in the second-year class. More than one-third of these disappear, so that sixteen per cent are found in the third-year class. More than one-third of these fail to reach their senior year, and ten per cent are found in the fourth-year class. A quarter of these are not allowed to graduate and eight per cent is the number of those who succeed. Half of these (four per cent) through "toil and trouble and tears" have prepared for college, and the colleges think they are doing the Lord's service by rejecting half of these, so that two per cent enter. There are plenty of people who raise the question whether these are superior or inferior to those who have dropped out by the way. These figures tabulated present the following appearance:

Of high school pupils in New York state, there are forty-eight per cent in first-year class, twenty-six per cent in second-year class, sixteen per cent in third-year class, ten per cent in fourth-year class, eight per cent graduate, four per cent prepare for college, two per cent are admitted. These statistics do not differ ma-

[1] School Science and Mathematics, March, 1915, page 220.
[2] School Science and Mathematics, November, 1915, page 685.
[3] Teachers College Record, November, 1915.

terially from those shown by the United States Commissioner's report for the high schools of the whole country.[4]

The project method in science is nothing new, though the name often calls forth an attack because it sounds radically new. It is nothing but the method of an Edison, a Pasteur, Faraday, Davy, Galileo, or Archimedes.

Pasteur, working on his asymetric crystals of tartaric acid, came near being caught in the obscurity of university research, but Dumas called him to a real project, the elimination of the silkworm disease that was causing a loss of 20,000,000 kg. of cocoons to France each year. He was not a technically trained biologist, but having *felt the need*, the problem became *vital*, he threw all his *energies* into the work, to the *study* he brought the resources *from many fields*, experimenting, *testing*, proving, until the result was obtained.

Then followed that wonderful list of projects, growing out of the needs of his day. The story of every great invention is the story of a project, and in it we find the following elements—

A *felt need*, real, vital, growing out of the unanswered part of one's *environment*.

A growing *interest* and enthusiasm calling for one's best *energies* and resulting in *activity*.

A broad, comprehensive *search* for related material.

An *organization* of the results of personal activity for solving the given project. This summary does not differ greatly from Dewey's analysis of the complete act of thought.

Too often we make the mistake of considering the school, separated from the actual life process, as a preparation for later living. As a noted educator puts it, "The world of studies then becomes a strange, peculiar world cut off from—abstracted from —the world in which pupils as human beings live and act and suffer."[5] The school is a part of life, and not merely a preparation.

President Suzzalo says, "The major difficulty of our schools is that they do not adequately enlist the interests and energies of children in school work. Good teaching, the teaching of the future, will make school life vital to youth." "In so doing it will not lose sight of the demands and need of an adult society; it will serve them better in that it will have a fuller cooperation of the children."[6]

[4] SCHOOL SCIENCE AND MATHEMATICS, 1913, pages 294-298.
[5] Dewey, *Interest and Effort in Education*, page 93.
[6] Introd., *Interest and Effort in Education*, page vii.

"It is absurd to suppose that a child gets more intellectual or mental discipline when he goes at a matter unwillingly, than when he goes at it out of the fullness of his heart."[7]

We want genuine interest, not interest through fear of a teacher, fear of failure among mates, or through a false emphasis on passing marks. We want *identification of student* through action with a project, the *value* of which he personally *feels*. The mistake is made in overlooking the activities and instincts of the child in his daily life, or in assuming that they are too trivial for purposes of education.

To quote from J. B. Bradley, Headmaster in Beadle's School, *Broad Lines in Science Teaching*—"Our aim must be—to teach him something about, well, not our everything, but his everything, the external world as it presents itself to him, not, that is, in the form of botany or 'mechanics,' or 'electricity,' still less as matter, force, gravitation, evolution, and the other ways by which we cheat ourselves into supposing we know all about a thing by naming it; but rather in the form of interest leading to investigation of all his surroundings."[8]

We have tried the "pouring in process" long enough—pouring in a boiled-down, devitalized physics obtained from college sources. "One may fairly say that intellectual absorption is the chief thing now expected of the modern urban child," says DeGarmo. "His attitude is that of a listener, he is a being to receive impressions. He must store his mind with facts deemed important by his teacher."

After a boy or girl has been forced to perform the experiments on index of refraction, coefficient of expansion, Hooke's law, Charles' law, Gay-Lussac's law, or any of the other thirty-odd experiments, is he not sure to ask, "Well, what is the use of all that? What use is physics to me?"

The boy who is a member of the Amateur Wireless Association of America, with a complete station of his own, and is then forced to work out Ohm's law on a Skidmore stand, might be compared to a General Goethals forced to run a typewriter all day in a down town office.

Each new day should set its new problems, which in turn should incite thinking to solve them. How many situations in

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[7]Dewey, *Interest and Effort in Education*, page 1.
[8]*Broad Lines in Science Teaching*, page 11.

so-called "preparatory" physics have elements in common with the real needs of life?

A recent textbook for girls starts the topic of light with that most engaging and useful topic, the photometer. It has less than four pages dealing with color. Nine lines are devoted to the mixing of pigments, yet it does not mention the matching of colors, shades for lamps, color blindness, or testing the eyesight. In italics we find the words, cornea, aqueous humor, iris, pupil, crystalline lens, vitreous humor, retina, optic nerve, choroid coat, sclerotic coat, yet it does not mention how to test a camera, how to buy an opera glass, interior decorations, lighting, what causes twilight, or why is there a circle around the moon. Four pages are devoted to the theory of refraction, discussing the sines of the angles, and four pages are devoted to optical instruments. Of the twenty-six so-called illustrations, twenty-three are line drawings tracing the path of rays of light through transparent bodies.

Remembering that only two per cent take the college courses, how often will the lawyer, the clergyman, the merchant, banker, yes, or the worker, the chauffeur, the shopman, ever consult his high school physics to solve his problem?

"There is only discipline when one can put one's powers economically, freely and fully at work upon work that is intrinsically worth doing."[9]

The project then is not formalized but grows out of the needs met in one's environment.

The project method recognizes native instincts and individual differences.

The project method recognizes that there are many different stimuli and as many responses to the project in hand.

It recognizes that interest growing out of identification of the self with an activity means growth.

Our duty as teachers is to direct these project activities between certain broadly defined limits, each individual path leading in the direction of our educational goal.

[9]De Garmo, *Interest Related to Will*, page 32.

RAILROADS, THE LARGEST CONSUMERS OF COAL.

The railroads of the United States used 128,200,000 net tons of coal in 1915, or twenty-four per cent of the total output. The bituminous mines furnished 122,000,000 tons, or twenty-eight per cent of their production, and the Pennsylvania anthracite region 6,200,000 tons, or seven per cent of its production. These figures are compiled by C. E. Lesher of the United States Geological Survey.

CIVIC OR SOCIAL BIOLOGY.[1]

By Jean Dawson,
Normal School, Cleveland.

United effort is the central idea in civic organization, and its extension underlies advance in civilization. Civic biology consists in that group of problems in the control of living nature to solve which requires that a community unite in working together intelligently.

We are suffering enormous losses—in destruction of natural resources, in unfruitful labor, in damage to property, in preventable disease—due to lack of proper civic organization. One ignorant or careless member of a community may kindle a forest fire, or clear a watershed that will cause a water famine over an extensive territory. He may permit insects or vermin to breed, or allow fungi or bacteria to grow, that will cause great damage to property, and disease and even loss of life among his neighbors.

It is a slight matter to extinguish a match or a camp fire; it may require the strenuous efforts of thousands to cope with a burning forest. So with every member of a community cooperating intelligently, slight effort may achieve great results, utterly impossible unless all work together.

Civic organization applies not only to the control of injurious forces, but equally to saving valuable species from extermination. Lacking such organization, a number of species of great value have already been exterminated from vast areas, and several more are in imminent danger.

The purpose of a course in civic biology is thus to cultivate habits of observation, insights into the workings of living nature, and, above all, civic ways of thinking and civic methods of studying and of attacking such problems; and the highest product of the course will be citizens who know enough to work together.

There is a large body of biological problems, the solution of which are vital to the health, resources, property, and even life itself, of every citizen, and a knowledge of these problems must enter as a part of the education of every boy and every girl, for in no other way can they be solved.

In all parts of our country these civic biology problems are legion, the great difficulty being the choice of the problem that should come first. In Cleveland, we chose the elimination of the filth-disease fly as our major problem.

In the past, I have written several articles on the material that

[1] Read before the Biology Section of the meeting of the Central Association of Science and Mathematics Teachers at Chicago, Nov. 26, 1915.

should enter a course in civic biology for the Journal, *School Science and Mathematics*. Today therefore, I shall content myself with the consideration of a problem that is well under solution, believing by doing so, that I can offer my audience no better illustration of an ideal type of civic biology and no more excellent example of how people may be brought to work together intelligently than can be found in an account of the Cleveland Anti-fly Campaign. It is, therefore, for the purpose of illustration that you will be invited to follow some of the details of this community struggle against the ravages of the most deadly of insect pests, the housefly.

Persistent effort on the part of the people for over a period of four years has so reduced Cleveland's fly population that it has served to attract the attention of the entire country as well as many countries abroad, including China and Japan. Answering the letters concerning the running of an anti-fly campaign alone, often taxes the office force to the limit. Nor do the number of these inquiries abate. Each succeeding year adds weight to our mail; interest radiates from the officials of city governments, colleges, universities, high schools, civic leagues and women's clubs. These inquiries are mentioned here because they tend to show that the abatement of the fly nuisance is a vital civic problem the world over.

Far be it from me to attempt a review of the history of the Cleveland Anti-fly Campaign. A small volume could be written, detailing the struggle to finance the movement, to educate the public to the dangers of the fly, its habits and life history, its capacity for carrying disease, the best method of eliminating it from the city, and, above all, to get the people united to act. From the beginning, the idea uppermost in our minds was to unite the entire community so that we could put forth a supreme effort in ridding the city of flies. To this end the small pamphlet, *Questions on the Housefly,* was published and widely distributed. In the city schools, both public and parochial, lessons were given on the fly as a part of their regular class work. A scenario was written and a motion picture made of the Cleveland campaign. Mayor Newton D. Baker, May Buckley, the popular actress, and hundreds of other people, including many school children, at work cleaning the city and swatting flies, were caught by the camera. The film involved enough pathos, humor and human interest to be shown for weeks in the leading theaters, holding its own on the regular vaudeville programs. Four of the largest

daily papers and several foreign newspapers devoted much space to the work of the campaign. Public interest was stimulated largely through news items, poems, songs, cartoons, human interest stories and every device known to the newspaper world. Forgetting business rivalry and their differences in political views, the public-spirited newspaper men of Cleveland are doing a piece of constructive work that may well be emulated by other cities of America and for that matter by the whole world.

The anti-fly movement is centered in the city schools and serves to illustrate a type of education which unites the forces of a community, the home, the church, the school, the city government and the business world, and teaches them to do team work as it were.

The campaign began the spring term in the year 1911 in the civic biology class of the City Normal School. This school receives girls, graduated from approved high schools (no men ever apply), and in two years' time turns them back into the schools to teach the young the art of citizenship.

During the years that we have run the campaign, our methods of attack have varied but little. We begin in February and March and strike the enemy a heavy blow by killing off the over-wintering flies before they have a chance to breed. The distribution of 300,000 or more fly swatters to the school children by a large ice-cream firm, together with our offer of ten cents a hundred for all flies brought to Anti-fly Headquarters, puts a death penalty on every fly that ventures from its hiding place. Boys spend their leisure hours in the most likely places for flies, while little girls carry their swatters back and forth from school, so as to be ready for the unwary fly that may cross their path. When we first began heading off the fly population by offering a bounty, people thought we had gone insane. It caused much criticism and it brought forth editorial comment from many newspapers from different parts of the country. It was not guesswork on our part. We were after the breeders and we know that in running an anti-fly campaign, human brain and effort must be pitted, not against the fly's wisdom or cunning, but against its marvelous powers of reproduction which can be calculated only by geometrical progression.

After reducing the number of over-wintering flies, we attempted the first season to hold the fly population in check by poisoning and trapping alone. While the public spoke of the scarcity of flies, we were not wholly satisfied and we felt that

reducing the number of flies after they had hatched is much like a person sopping up water from an open faucet, in itself a necessary step, but not a permanent measure. Henceforth, we determined to go deeper and strike at the root of the fly nuisance. It was with the hope of closing the faucet that we began to devote much of our time to cleaning away the fly's breeding places.

To the public, the appearance of flies was surrounded in mystery. "Might as well try to curb the wind," was the comment that was current when we first announced that we were going to hold the flies in check. However, all mystery and all thought of a dispensation of providence disappears when the simple truth is known. I believe that the work of ridding the city of flies is in a great measure accomplished when the rank and file of people realize that fermenting organic matter is the only material upon which fly larvæ can feed and that as soon as the city is kept clean, the mother fly has no chance of perpetuating her young.

At the beginning of the second year, a six weeks' investigation of neighborhoods in the different parts of the city revealed the fly-breeding places. Fortunately, the millions of eggs and larvæ found in exposed garbage were killed at the garbage-rendering plant before they developed into mature flies. It is only in the outlying districts where collections are infrequent or where it is allowed to lie upon the ground for more than a week, that flies mature in the garbage in Cleveland. The city also disposed of its sewage so that there was left but one source of organic debris that could breed flies in numbers, i. e., the manure from stables.

A general survey showed that neglect characterized the conditions of the stables throughout the city. North, east, south and west, stable refuse was allowed to accumulate, usually in heaps on the ground, without even a board to keep it from being scattered over the yard. Nor was this condition found in the poorer districts alone; stables back of Euclid Avenue stores and those back of grocery and hardware shops in some of the most select residential sections were not cleaned in weeks and even months.

It was about horse stables (5,000 or more in number) that fully ninety per cent of the flies of the city were breeding. "But," you ask, "does Cleveland not have an ordinance that compels the stable owner to remove the manure once every twenty-four hours? Most cities have." To be sure there is such an ordinance, and the first stable owner that was reminded of this fact replied, "Yes, I'll remove the manure from my stable box once a week as you

suggest, and be glad to, if you will tell me where I can put it." Unconsciously, this man summed up one of the greatest difficulties of ridding a city of flies, i. e., the disposal of stable refuse, especially that from the one-horse stable. The city had passed an ordinance to remove stable refuse years before, but unfortunately, it had provided no place to dispose of the refuse. To be sure we might have been unreasonable enough to have insisted that the man hitch up his horse and draw a wheelbarrowfull of manure (a week's accumulation from a one-horse stable), miles and miles to the city limits, so that the law might be obeyed, or, if he did not care to do this, we might have told him to pay the customary three dollars a load to an expressman to have it removed. Had we attempted to enforce so unreasonable a law, the anti-fly campaign would have died from want of backing from the masses of common-sense people. It was clear to us that if the law was to be enforced, it must first be made reasonable. With some difficulty, seven switch tracks were located where manure might be loaded and shipped on cars out of the city. This method proved successful in the congested parts of the city, but in the residential sections there was not manure enough to fill a car before the flies began to breed in it. The past season we remedied this defect. We gave up the loading stations and established one or more large boxes in each ward where manure could be dumped by the stable owner. The boxes in turn were emptied by truck gardeners who were glad to collect every day or two for the price of the manure. This method was immediately successful and is without doubt the most satisfactory that can be devised until the city becomes financially able to collect stable refuse as it does the garbage, ashes and rubbish.

After making the law reasonable, it remained for us to enforce it. It soon became clear that the only means of cleaning a city and keeping it clean is to maintain a systematic weekly inspection. The city council seeing this need appropriated $2,000 to be paid for salaries to such people as we saw fit to employ.

Fortunately, the help problem did not enter to complicate matters. Normal school girls rallied to our call and soon thirty enthusiastic inspectors left the Anti-fly Headquarters daily, each scheduled to inspect weekly a portion of the fifty-five square miles of territory of which Cleveland is composed. It is but fair to say in passing, that much of the success of the campaign is due to the indefatigable work, courage and pluck displayed by these young women. Teachers to be, they distributed much biological

knowledge while on their trips. In return they received $7.50 per week and they gained much first-hand information of the city and condition of the homes, which will be of inestimable value to them in their future work of instructing in the ways of better living.

Thus far you have had but a bare statement of facts. Should you care to get a view of a people working out the details of a civic biology problem at closer range, come to the City Hall at 8:00 o'clock on most any day in summer. From the first of March until the middle of May, our office was located on the ground floor. During this season, a mob of boys and girls, carrying dead flies in tin cans, cigarette boxes and bottles of all descriptions, invaded the Anti-fly Headquarters from 3:00 o'clock until 6:00 for the five school days, and practically all day Saturday. Should we have attempted to have this crowd taken on the elevator to the fifth floor, where we are now located, we would have blocked traffic. During the summer months the work changes completely. Instead of people coming to us, we go to the people, and it is necessary therefore to have a reasonably quiet and secluded room in which we may discuss the conditions found in the various parts of the city.

Upon reaching the office, we find that the Secretary has not yet arrived, but standing before the closed door is a group of boys who have come to get free swatters for all the children of "Progress City," an organization of one of the social settlement houses. We set the boys at work counting out swatters in bundles of one hundred each. No sooner have they departed than other boys arrive who ask for a like number of swatters. Upon questioning them, it develops that they have seen the "Progress City" children with their swatters and devised the scheme of getting the swatters and selling them on the street for pocket money. Needless to say, the boys go away empty-handed and we straightway make a ruling that no group of children can hereafter get any number of swatters without an official note from the head of their organization.

The 'phone rings, and we pause to answer. A dog has died under the porch of a certain house we are informed, but has been dead for several days and the neighbors are highly incensed that they can get no one to take it away. They appeal to us as the last resort. We turn to call up the Superintendent of the Garbage Collection, who promises to send the dog-wagon to the rescue as soon as it returns from a trip. While we are speaking

we remember that there are certain complaints about garbage about which we wish to speak. Rumors have reached our office that at a certain number on a certain street the garbage is not collected regularly. We tell the Superintendent that we are aware that false accusations are made by householders but we wish he would investigate to see whether the collector is really doing his duty.

We scarcely have hung up the receiver when the phone again rings. This time the complaint is from a man who says his neighbor's stable is too near his, the complainant's house. We refer him to the health commissioner and explain that the Anti-fly office takes up complaints concerning stables, only when they have become a fly-breeding nuisance.

We glance at our desk. There is a complaint there from the previous day. A man says that to his knowledge a stable near his home has not been cleaned for a month. We reach for our duplicate records of the ward in which the man lives and find that the inspector has missed that stable entirely. We are delighted to find the location of his stable as we have been speculating as to where the flies in this particular neighborhood have been coming from. It is not surprising that a stable is missed now and then. Horses are sometimes kept in the most unusual places—in the rear of a store; in a shed back of a house where the horse has to go through the house in order to reach his stall, and even in houses themselves. Nor is the inaccessibility of a stable the greatest difficulty—stable owners often cannot speak English and others are naturally suspicious or reticent about giving out any information whatsoever.

We employ two methods of locating fly-breeding places. After a thorough search has been made for all the possible stables, we begin the other way round and take a fly census. This method serves as a check on the other, for a weather vane indicates the direction of the wind no more certainly than the flies in a neighborhood indicate the presence of hidden filth.

It is 8:30 now. The secretary has arrived so we will make a hurried trip to the market and commission houses. We soon find ourselves in the most congested section of the city with a variety of business interests and crowds of humanity living in houses, the condition of which is absorbing the attention of the city's experts. There are five hundred stables in this immediate neighborhood, yet a broken melon lying in the street fails to attract a single fly. We pass through market and commission houses. Every-

where the windows and doors are unscreened, and yet were it not for the sultry weather one might almost think it were winter, so scarce are the flies.

From the beginning much time and effort have been directed toward keeping the flies under control in this district, because it has in it the central food supply of the city. We hold that it is of small use to urge the elimination of flies from the retail stores if the food is contaminated before reaching them.

"In past years flies rose like live steam before you as you passed in front of the stalls in the market," a merchant tells us. "Why, you could not tell the color of meat for flies in those days." We launch into the discussion of the changes the markets have undergone, when the market-master interrupts us with, "I beg your parden, you are wanted at the City Hall." As we prepare to leave, the merchant calls after us, "We are mighty thankful to you for getting rid of the flies, and if you ever run for office, you will have my vote and I know lots of others who will do the same." We depart, amused with the idea that all public workers are looking for reward in obtaining public office.

Back in the Anti-fly office we learn that the clerk of the Police Court has been making frantic efforts to get us over the telephone. It seems a large number of people whom we have summoned into court have arrived a half hour early and are blocking the corridors. We catch up the books and papers necessary and hastily make our way to the Police Station. Without delay we take our seats in the court room and begin to call off the numbers from our lists. These people have persisted in breaking the law even after they have been duly warned, so we have caused them to be brought into the court to try to straighten out matters without causing their arrest.

The first man is a dapper undertaker, indignant to find that he is called into court for so trivial a matter as a failure to remove stable refuse on time. Anyway, he has a notion to defy us. Isn't it his horse? We assure him that his constitutional rights are not being infringed upon. The horse is his and the manure is his to sell or give away as he pleases. But, we assure him, he cannot hold manure on his premises to breed flies, to spread sickness and disease among his neighbors. We also assure him that this is the last warning he will have, and that if our inspectors find him violating the law again we will swear out a warrant and cause his arrest.

The second man keeps a grocery store. He says he cannot

afford to hire an expressman and that he has no wagon in which he can haul manure. We tell him that if he puts the cleanings from his stable in a clean barrel and wraps it in canvas, that he can take it to the station without harm to anyone.

Number three is a milkman, indignant that the city does not collect from his stable. He pays $60 taxes he tells us and has a right to free service. We remind him that for that sum, he is getting free education for his children, besides such trifles as street lighting, street cleaning, police and fire protection, free garbage, rubbish and ash collections, and sundry other things too numerous to mention. Besides we remind him the city has not sufficient money to pay its household expenses; that it would take all of $150,000 to provide a free weekly collection from all stables.

Four is a woman representing her husband. She meekly declares that they will comply with the law. She confesses that she was much frightened when the burly policeman knocked on her door and handed her a summons for her husband to appear in court. We glance at our inspector's note on the case, "Says they will not comply. Woman very discourteous, even swore at me." With difficulty we restrain a smile and think what a wonderful influence for good our police force would have if the problems of sanitation were made a part of their regular work.

Five is an old man who cannot understand what it is all about. Why, he has kept a horse in Cleveland long before we were born, and not until now has he had anyone say aught to him about how he has kept his stable.

Six is the owner of a greenhouse. He says he must have manure if he is going to run his business. We suggest that after this he buy his fertilizer in the winter months, as manure after it ceases to ferment cannot breed flies. We tell him that we will concede a point to professional gardeners. If they will spray manure with a borax solution, so that flies will not breed in it, as the United States government is suggesting, we will not interfere.

Thus we go on until the noon hour. Nearly all have the excuse that the farmer who usually collected from them is too busy with his crops to come to town. Milkmen and grocerymen are greatly in evidence in breaking the law, and strange to say, they are the most reluctant in saying that they will comply.

Truly it is a veritable schoolroom and the lessons taught are on sanitation, and the rights of one's neighbors. We cannot help

but feel that this is an important part of the work of an anti-fly campaign. Were all these people made to obey the law, our city would indeed be flyless. Just how much sickness and death may be charged to their carelessness, we cannot estimate.

As we pass down through the police station, we pause to speak to the Captain, and give him the list of other stablemen to summons into court. The Captain is much interested in the work of ridding the city of flies. He thinks we are accomplishing wonderful results, but, he says, "it is a question in his mind whether it would not be best to arrest on first offense, rather than spend so much time giving so many warnings." "Perhaps," we reply, "but the work of ridding the city of flies is largely an educational problem." We pacify him by saying that another year it will not be so new and we can enforce the law much more rigidly. At the beginning of the season the good Captain was loath to believe that it was a woman's work to rid the city of flies, but when we reminded him that it was really housecleaning, he began to change his mind; he is now an enthusiastic advocate of women for all sanitary inspections.

Luncheon over, we take a long ride in the cars to the stockyards. We go to the office of the City Meat Inspector. We marvel that we see no flies, for in former years, in spite of the traps on the outside, this office was swarming with a variety of flies. The Inspector informs us that there are no flies to speak of in or about the stockyards or abattoirs where we used to trap them by the bushel. We spend the greater part of the afternoon in investigating and find that the Inspector is right. Only in two places are there flies in any number, and in a short time we locate their source in the stables back of two provision houses.

We visit the superintendent of the stockyards. Government and city inspectors soon gather to discuss the scarcity of flies, and we are eager to hear each tell of the part he has played, in their elimination. Early in March, we met in this same office to lay our plans for fly warfare, and, lo, we have conquered; the breeding places have been removed. The stockyards have installed a machine that grinds and dries all cleanings from cattle pens and from stock cars as fast as they are unloaded. The inspectors of the slaughter-houses caused a thorough sterilization with live steam of everything and every place where meat or animal material of any kind was kept. With a caution to inspect weekly the neglected stables we had found, we departed, rejoicing that the great source of meat supply of the city is so well safeguarded from the winged disease carriers.

Back to the anti-fly office again we go, only to find it filled to the door with a bevy of earnest, healthy, wholesome girls, laughing over the funny incidents of the day. Listen to what one of the inspectors is saying. "The lady at blank number is always polite when everything is all right, but today I found the yard in bad condition. She came out when I was writing in my notebook, and she told me that I was in big business; that if she had a daughter she would not allow her to do such degrading work, and ended by saying that I had better be home washing dishes."

Notice that all these girls are wearing official badges on their wrists, much as a watch is worn. Look closer and you will read, "City of Cleveland, Department of Public Service, Sanitary Aide."

The girls have already written out all complaints and filed them with the Secretary. Notebooks in hand, they are waiting for further instructions. We tell them that as soon as they have finished the weekly inspection of the stables in their territories, to begin with the restaurants and all the stores that handle human food. If flies are plentiful in any part of their ward, they are to look for the breeding ground in that neighborhood. In the meantime, they are to tell the proprietor of such restaurants and shops to get rid of their flies in the next twenty-four hours by trapping or poisoning them. Report all failures to comply.

Can we do anything with the merchant who fails to rid his place of flies? Why, to be sure we can bring him to the prosecutor's court the same as we do for violations of the stable ordinance. Once is enough for all the merchants we have summoned so far this summer, as it is not good business to advertise one's place if fly infested.

As the inspectors leave the office, a little girl lingers to ask what can be done to prevent a man from chaining a cross dog in his front yard, so that she cannot inspect. We do not know, but we call up the Director of Public Safety to find out. "The policeman in that precinct will call there tomorrow and straighten out matters for you," we tell the girl, and she departs happy.

Do we always have such splendid cooperation from everybody? "All but from one source," we reply—The Bureau of Sanitation," and they have fought against us from the first. Why? Doubtless for much the same reason that the Boards of Health fought Dr. Ross in his work of ridding the Suez Canal zone of mosquitoes.

RESULTS OF AN INVESTIGATION ON THE PRESENT STATUS OF HIGH SCHOOL PHYSIOGRAPHY.

By Charles E. Peet, Chairman,
Lewis Institute, Chicago.

Preliminary Statement by Chairman.

The committee was continued from last year to discover the schools that, in the first-year high school physiography, produce results recognizable in college, and to study their methods. Letters were sent to the same college, university and normal school instructors that contributed the information reported last year. About one-third of the number sent replies, which may or may not mean that those not replying had nothing to add to their former contributions.

1. It was asked if any marked improvement in the results of the high school physiography in the last three years had been noted. Two-thirds of the replies were in the negative. The other third expressed the opinion that there had been a slight improvement, but in no case was it considered so great or so general as to justify the division of the college classes into those with entrance credit in physiography and those without it. At least one reply was based on the fact that the number of trained teachers is increasing rather than on improvement directly observed.

2. The names of the schools were requested where it was known that the course in physiography in the first year of the high school is so good that the results are recognizable when the students get to college. Two schools mentioned as coming the nearest to answering this description were in each case in the town in which the correspondent lived. One answer says: "Some students from the Chicago high schools have carried over some of the results of their work in physiography. In many cases, they do not remember a great deal, but they have a feeling for the subject, which enables them to acquire related material easily. Individual students from St. Louis, Minneapolis and various towns of Wisconsin and other states have had similar power."

3. The names of schools were requested in which the work is so good that it might be recognized by placing the students with entrance credit in physiography in separate classes in college from those who have not this credit. Ten schools were mentioned, of which five in Indiana were mentioned by one man and four in Colorado by another, the schools of one city in Ohio by another.

Another said: "I cannot supply you with a list of schools whose product is so universally good that the high school foundation might be recognized. I know of several good teachers who are doing excellent work, but the students do not seem to retain the subject matter. Physical geography is only one year nearer than the geography of the grades, and in neither case do the pupils seem to retain any great knowledge of the facts. What we look for at the present time is that the students who come to us have some ability to apply themselves intelligently and to think constructively. So much depends upon the individual student, rather than the nature of the course, that it does not seem probable that we shall be able to pick them out on the basis of previous work. I would prefer to use the ability of the student as a basis. Unfortunately, we cannot do this at the present but it would be an excellent way to check your proposition."

To sum up the results of this search: There are many schools that are doing good work in physiography in the early years of the high school, but there is little of the product recognizable three or four years later. We have been unable to learn of schools that produce in the first year of the high school an impression so lasting that they can serve as models to follow for this purpose. The schools that are doing good work and are recognized as doing good work have been regularly represented in these meetings and in the meetings of similar organizations in different parts of the country.

It was a surprise last year to learn that generally so little of the high school physiography was left when the student gets to college. It has been known for a long time, of course, that high school results were criticized, but we have thought that they were the results of the other fellow that were referred to.

The attitude at first concerning this poor showing is one of amused unbelief and one is likely to ask about a man making such statements: "What's the matter with him?" Then the attitude changes to one of doubt. So many say the same thing, there must be some truth in what is said. Then comes the conclusion that the statements are true. And finally: "Of course! We couldn't expect it to be otherwise."

The experience of some instructors who have passed from the high school to the university and there received their own high school students is very instructive. Professor Atwood reported his experience to a conference at the University of Chicago several

years ago. Another instructor in physiography in one of the great universities in the Middle West told me that the students he taught in the high school before going to the university were no credit to him when they came to the university. His high school principal was very much surprised that this should be true of the work of a teacher who was so full of enthusiasm for his work and so well prepared that he was called to the State University.

There very likely are those among us who have been careful not to omit anything from the course for fear that it might be a disadvantage to some student after he gets to college. It is well for us to know that the high school foundation is not so important that the omission of a topic here and there will cripple the student in his college work in this subject, and that these omissions will not "introduce confusion and lower the standards of work in the universities," as some one has recently said about the introduction of elementary science in the high school. It is well for us to know the truth. The truth makes us free to shape our work according to the needs of our students.

It seems that the college man has little interest in the knowledge we impart. His great interest is in the mental development, for which the teachers of physiography are responsible but for a small fraction of the total.

It is well for us to know that the esteem in which the high school man is held by the college man can not be high if it is based on the product sent to college. It is by the work we do for the student while we have him, not what there remains four years later, that we may fairly be judged it seems.

The report of the high school results in physiography were so discouraging, to give them proper value it seemed desirable to learn what are the results in the other high school sciences. Misery loves company. Are we alone in our misery? The same questions which had been sent to college instructors in earth science were sent to the college instructors of other sciences commonly represented in the high school curriculum. Here are some of the replies:

Results in High School Botany.

"We do not find that the college or university course in botany can be built on the foundation laid in the high school.

"We do not distinguish in our elementary course between those

students who have had high school work in botany and those who have not. Our experience has been that there is practically very little difference between these two classes in their ability to master the subject as presented in a university.

"My answers to the foregoing questions do not, I think, necessarily imply that the high school work in botany is unsatisfactory. The purposes of the high school course in the subject given in the first or second year of high school are radically different from the purposes of a university course. The method of treatment in the two should be equally different, and it seems to me that it follows that the one cannot in any real sense be a preparation for the other. Even if more similarity between the two were possible, the lapse of three or four years between the time of taking work in botany in high school and the time of starting it in the university would destroy any possible continuity. It is true, of course, that the high school work in botany is by no means satisfactory. The same, I think, may be said of the high school teaching in any subject. I am inclined to think that the greatest source of trouble is in the poor quality and poor preparation of the great majority of high school teachers. Improvement must come, if at all, more through a raising of the standard required for entrance into high school teaching than through any possible amount of tinkering with the content or arrangement of high school courses."

Another says: "My introductory biology is so different from the high school work that the high school botany does not seem to matter. The high school botany seems to be all right for training, but the students do not seem to know any botany. They forget it all before entering college."

Results in High School Chemistry.

Concerning chemistry, one reply says: "College classes are divided into separate divisions for those who have and those who have not had the subject in high school. The high school work is unsatisfactory in the lack of knowledge of the subject except in some special cases, generally from some of the larger schools. They know some general things about the study, but after the first six weeks of elementary points the subject is practically new to them. The chief reason for the unsatisfactory results is the quality of instruction in the high schools. In the larger schools where good instruction is given, the students are satisfactory. Fully fifty per cent of the students have, however, been under very inefficient instruction."

Another says: "We do not build on the high school work in chemistry. Two years ago, we had those with high school credit in the subject in a separate division, but we have discontinued this, for at Thanksgiving time there was no visible difference between the sections. The fact that we can not build higher college courses in chemistry upon high school chemistry is not a criticism of high school work in any way. We feel that the high school must principally serve those that do not go to college."

Results in High School Physics.

Concerning physics, we have the following letter: "In reply to your recent inquiry, I take pleasure in saying that in this university we do differentiate between the different preparations which our students have had in the various high schools, and that we have one course of physics to which we admit only those who have had the training of the better and higher high schools, and an entirely different course for those who have had less extensive preparation. Into the latter class are admitted also a few students who have never before taken the subject of physics, but this number is so small as to have but little effect.

"I beg to say also, in reply to your third question, that there is one great lack which I think the high school could remedy, and which I hope you will do what you can to correct, and that is teaching the students to think, and especially teaching them how to study. My greatest difficulty with students, as they come to me from the high schools, is that they do not know how to study, and I find that fully a third of the year goes by before these students know what study means, or how to apply themselves, with their minds concentrated assiduously upon what they are doing."

The progressive improvement in results from the earlier years to the later years of the high school is an interesting fact and is, of course, just what would be expected under the present arrangement of isolated sciences. Although the replies are not gathered from a wide area, and in large numbers, these facts are probably representative. They are in accord with information obtained through conversations with instructors in these subjects.

The statements show that all the high school sciences suffer from a common malady—poor instruction. But in all subjects it is recognized that there is some good instruction. It seems that the results of the sciences in the early years of the high school are negligible, that those of the later years are recognizable, but that in general the students are deficient in thinking power.

REPORT OF THE COMMITTEE.

A number of reasons for poor results in high school physiography were given in the answers to the questionnaire published last year. The summary is as follows:

1. No definite aim.
2. High schools attempt too much. They are attempting the impossible.
   a. There are too many subjects.
   b. Too many things are taught under the name of physiography.
3. Immaturity of the student and his ignorance of physical science and ordinary geography.
4. The subject is too difficult and abstract, and is inappropriate for first-year work. The texts are too technical.
5. Teachers do not understand the subject.
6. Teachers do not have an interest in the subject.
7. Teachers are untrained.
8. There is too little field work. The work is too bookish.
9. The laboratory and illustrative material are inadequate.
10. Facts instead of principles are taught. Descriptions instead of solutions of problems are required.

We would add that one great disadvantage from which the physiography has suffered has been its isolation. It has not been related to the subject which the student has taken in the grammar school, and oftentimes it has not been related to the experiences of daily life of the student. This is especially true in large cities with students who have had no opportunity to travel and where the difficulties of field work are so great that it is hopeless to expect progress along this line. This isolation has not been relieved by use of the knowledge obtained in its study in the subjects studied later in the high school. The knowledge commonly has not been used enough to give the student an appreciation of its value to him.

It is one of the merits of the movement to expand the course in high school geography to include more of the human relations, that it gives the student a chance to use his knowledge of the physical geography, and by so using it he will come to appreciate it. But unless it goes beyond this, unless we secure the cooperation of our fellow teachers in the later years of the high school in getting these young people to use this knowledge in their later work in science and history and literature, we may be sure that as now, there will be little left at the end of the high school course. The expansion of the course upward into the study of life—and especially of man and his relation to his environment—is a big step in advance.

There has been no time in all its history when geography could be taught to such an advantage as at the present. With the mov-

ing picture, the lantern slide, and the traveling museum, the world can be brought right into the schoolroom.

But those who expect lasting results from it in the immaturity of the early years of the high school are doomed to disappointment. This expansion of the course in physical geography answers the student's question of the value of the subject to him, but it does not make the knowledge perpetual. I speak from fifteen years' experience with this sort of expansion of the course in physical geography.

If this country ever adopts a system of universal military training, the opportunity will come for the boy to use his knowledge of physiography, and it will then be recognized that a service to the country is rendered by training the student to read the topographic map. In the Russo-Japanese war, General Kuropatkin complained that the Colonels even in his army could not read the maps, not to mention teaching others to read them.

The truth of the matter is that the great difficulty with our work in the city is to get the student in contact with nature. There is not money enough to carry on the work in the way it should be carried on. A system of summer camps for military training, in which training on topographic work enters so largely, could solve the problem of efficient instruction in physiography. It would come at a time when the outdoor life would be of the greatest value to the growing boy and at a time when his summers are otherwise of the least value to him. Until we get help in some such way, there is little hope for much development in the direction of work in the field for the children in large cities.

One reason for the failure of physical geography where it has been a failure is the surprising one that it has not been recognized that the student and his interests are in large part a response to his environment. The great things in the whole problem—the student himself and his interests—have been little considered. There is no reason why the physiography courses in different localities should be alike. So far as the colleges are considered, we are free to adapt the work to our students without any regard whatsoever to anything else. No subject has any right in the high school curriculum except as it justifies itself by its results.

There can be no doubt that the poor preparation of the teacher is responsible for much of the poor results in our high school geography. No census has ever been taken which would show the preparation of all the instructors in this subject in any one state so far as we are aware, but questionnaires have probed this matter

in Illinois, Indiana, Michigan, Iowa and other states. The results of these different questionnaires are so harmonious that there can be no doubt of the facts. Yet it is doubtful if the results would be generally recognizable in college, even if all the instructors were as well prepared to teach the subject and were as good teachers as the best. The truth of the matter is, as the majority of the college men admit, that it is unreasonable to expect these fourteen- and fifteen-year-old children to retain for three or four years much of that which they learn in the first year of the high school and never put to use.

Last year, the attempt was made to learn whether the physiography is gaining or losing in the schools, by a questionnaire sent to schools in the Middle West that had adopted Clark's *General Science* for a textbook. Sixteen per cent of those replying to the questionnaire had dropped the physiography. In thirty-five per cent of the schools replying to the questionnaire, the position of the physiography had been affected by the introduction of the general science—that is, the subject had either been dropped, cut to one-half year, or changed to another year. The number of schools giving general science courses this year, as near as can be estimated—and it is only a rough approximation—is in the neighborhood of 3,000 or 4,000. Taking the smaller figure, if the same ratio holds good, physiography has been affected in more than 1,000 schools, and of these 500 have dropped the physiography, and 300 have cut the course to a half year. It is probable, however, that the ratio of the number of schools in which physiography is affected to the total number adopting general science is larger, for several of the newer texts are more physiographic in their nature, and the publishers say they are displacing physiography.

Of one book, however, the publishers say that in sixty per cent of the cases it is not displacing another science, but where it is displacing another science it often is agriculture, biology, botany or zoology. The exact situation should appear in the statistics of the Bureau of Education. These rough approximations obtained from the different publishers of general science texts suffice to show that a rapid change is taking place. That physiography is to be most affected by the change there is little doubt.

CHARLES EMERSON PEET,
ALISON E. AITCHISON,
Committee.

LABORATORY TEACHING.[1]

By H. N. Goddard,
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I. Introduction.

Problems of science teaching, as of every other live subject, are always with us. We have undoubtedly made much progress in recent years, but advance is too apt to take place in a zigzag path rather than in a straight line. Our enthusiasm and confidence in a new departure are always in danger of leading us too far and of blinding us to weaknesses and defects which creep into the new plan. The result is often much loss in swinging back and forth from one extreme to another. What we need for the best progress is educational balance which enables us to keep our eyes fixed on ultimate results, and leads us to be ready at all times to modify our method whenever it is apparent that it is failing to adapt itself to the turning out of the best possible product.

The laboratory movement was undoubtedly a great step in advance over the old bookish, abstract method of science teaching. While this is true, it has also been a matter of frequent comment in recent years that the results which were expected from this method of study have not been fully realized. It is common knowledge to those concerned with the problems of science teaching, especially in the high school, that students in large numbers have taken pains to steer clear of laboratory courses, either because they thought these courses took too much time, or because the notebook and drawing work generally required in these courses were thought to be too tedious and irksome.

Even students who have taken the courses, while finishing with creditable standings, have yet developed little in the way of permanent interest in the subject or desire to know more about it. Instead, in many cases, students have left the work with positive dislike or even hatred, whereas, according to our commonly accepted theories, science subjects ought to be the most interesting and the most practical of any in the school curriculum. Furthermore, students who have done creditable work in science courses often seem to show a strange inability to apply any of the principles learned to the commonest and simplest everyday problems and phenomena. I do not claim that these weaknesses are

[1]Paper read before the Physics Section of the Wisconsin State Teachers' Association, November, 1915.

by any means universal, and I recognize that much improvement has been made in the last few years. I do, however, insist, after a number of years of careful study of science work in the schools, especially in the high schools during the last few years, that these conditions are yet entirely too common in current practice, far more common than would be suspected from current educational discussion along this line. Indeed, it is a matter of frequent comment among inspectors that often teachers, who have excellent ideas of educational theory, are not themselves successful in carrying these ideas out in their own practice. This is no discredit to these teachers. It is simply because habit and tradition, when deeply fixed, often change far more slowly than current theory.

Authoritative expression has recently been given to the general prevalence of these defects in the *Preliminary Report of the Committee on Reorganization of Secondary Education,* appointed by the National Educational Association in 1913. This report says:

> Certain defects of science courses in content and in methods are becoming increasingly apparent. In some respects, science teaching is not as closely related to the environment and experience of the pupil today as it was a quarter century ago. With the elaboration of apparatus and the increased attention to quantitative methods, there has come an aloofness from the experience of everyday life, so that the pupil may secure a high standing in physics, chemistry or biology without necessarily gaining an understanding of their applications. Moreover, teachers in science in some instances overemphasize the importance of formal and fixed procedure and, as a result, are not alert to utilize new opportunities.
>
> The failure to adapt science instruction to the real needs of boys and girls has resulted in lack of interest on the part of the pupils and, in many schools, altogether too small a percentage of the pupils elect science courses. It is obvious that science teaching will profit greatly when the experience of instructors in many high schools becomes common property."

Perhaps the greatest source of these defects lies in our methods of laboratory work.

II. Origin of Laboratory Work.

It is interesting to notice the influences which have most largely determined the character of this work in the secondary schools. Laboratory methods were first developed in the colleges. From them the idea was carried to the high schools, partly by teachers trained in the colleges, and partly through college entrance requirements. In 1886, Harvard College became a leader among colleges and universities in demanding laboratory instruction as an entrance requirement. This requirement rapidly became gen-

eral, and such work began to be introduced into the high schools, according to Kester, in the early eighties. At the same time, textbooks and laboratory manuals, written for the most part by college men, or men in preparatory schools, began to appear for use in the high schools. Gage's *Elements of Physics,* one of the earliest books based on the laboratory plan, came into rapid and extended use. It was natural enough that the work laid out for high schools by college men should be largely a diluted and perhaps somewhat simplified form of college work, but nevertheless technical, and presented according to the specialist's notion of logical arrangement. Results were often expressed in technical units and formulas and reduced to abstract statements difficult for the young student to understand. As new methods have been developed in the college study of science, these new methods have been carried back almost universally into the high school. As quantitative experimentation became refined and perfected, and the sciences came to be organized more upon quantitative ideas, this quantitative work became general in the high schools, and refined and expensive apparatus was put into the hands of high school boys and girls, who were expected to develop great scientific power by carrying through long and tedious experiments, the results of which must be expressed accurately to the fourth decimal place. Such work has been aptly referred to by one author as "starvation courses in measurements." We are now pretty well through this period, although in the last few months I have seen a number of physics teachers in Wisconsin starting their classes out with refined measurements by the use of accurate scales, micrometers, calipers, etc. The introduction of microscopic work in biology into the high schools is a striking example of the tendency to carry back refined college methods to the secondary schools. Such courses are now rare, although during the present year in a large high school, practically a first-year college course in microscopic botany was being given to third-year high school pupils.

Textbooks and laboratory manuals have been largely of the technical sort up to the present time. It is interesting to note, however, that one or two authors, in attempting recently to adapt physics to girls, have ventured to abandon completely the long-established notion of logical arrangement of topics.

During all this earlier period of laboratory development, little study was made by the makers of texts and manuals, of the natural interests and mental processes of high school pupils, or the

practical needs of the large per cent of students who never go to college, but who go out after high school work to meet everyday problems. Work was outlined from above by the specialist. It was then imposed upon the student, who was told, "Here is what you must do, and here is what you ought to know." Few efforts were made by those who knew their subject, to try to organize the work on the basis of the development of pupils through the grades and upon their interests and capacities as determined by previous training and experience before entering high school.

The more recent period of development has been one in which science teachers and textbook writers have been studying especially the practical values of science study. It might be called the period of *practical science*. During this period, applications to domestic science, agriculture, industrial processes and the problems of everyday life have been receiving large attention, and much improvement has resulted, though new dangers have been encountered.

We are at the present time just beginning to enter another period of development in science teaching, and especially in the teaching of physics. The predominant idea of this period will be how to adapt the subject matter and methods of work to the natural interests and capacities of pupils. Here we shall look upon method and logical arrangement from the standpoint of the pupil, not from that of the mature mind or the expert after years of study. Topics and methods will be chosen in relation to the previous experiences of the pupils and to the natural processes of thought in the young mind, rather than in relation to the order and method, thought to be scientific by the specialist. The natural development of science with the race has not been from above downward, but from below upward. The child can at first organize only small units of thought, and then only in relation to his own experiences which are few. With growing experience and knowledge, he can comprehend larger units and organize larger relations. His natural order is from the superficial and the particular to the more abstract and fundamental. He does not naturally begin with the fundamental as the mature and experienced mind often does. We have too often demanded, or at least expected, that the child be able to master these larger and more fundamental conceptions at the outset. Again, technical terms, definitions and formulas are the result of perfectly developed scientific conceptions. These terms and formulas become only an incumbrance and a source of confusion if thrust upon the

young mind before the corresponding idea or concept has been clearly developed.

III. Specific Application to Laboratory Methods.

If now we attempt to apply these general considerations which are recognized by all science teachers, it becomes apparent that many of our laboratory experiments are too technical and involve too much tedious and irksome quantitative work, which is little related to pupils' experiences and practical needs. For example, in a large high school I recently saw a student who was trying to find by experiment the specific gravity of bodies lighter than water. A few questions showed plainly that the simple ideas of density and specific gravity had become hopelessly confused by technical definitions, the principle of Archimedes, etc. In another physics laboratory, two young ladies had a whole table covered with papers which they had filled with computations. They were trying to find out the relationship between pressure and depth in relation to densities of various liquids, and were trying to express their result in the form of a constant. A few questions showed they had little idea of what the real problem was, and no idea at all of the meaning of the result when obtained. The only answer they could give to the question as to what they were trying to find out was: "We are trying to work the experiment with that apparatus over there on the wall." Similar instances could be multiplied many times from observations in the laboratories of the country. This last illustration shows that technical and intricate mathematical calculations, at least so to the pupil, often confuse results so that students fail to see significance or meaning in these results when obtained. Likewise, elaborate and tedious notes often deaden or destroy all interest or even lead to dislike of the subject. One pupil, after a year's work in biology in one of the largest high schools of Wisconsin, recently said that it was her feeling that all interest and appreciation of the subject had been spoiled by the constant pressure of writing up notes and making drawings. I do not think this case is exceptional.

IV. The Greatest Defect of Present Laboratory Methods.

But these are not the worst difficulties in the usual laboratory methods. A more serious defect lies in the fact that the common method employed lacks motive on the part of the pupil and, instead of stimulating interest and good independent thought, leads rather to the blind following of directions and to hurried manip-

ulations to get a formal result and have it credited. Because of this weakness, the present method has been called the "recipe method." The formal laboratory manual is perhaps the main cause of this defect. Again, requiring all pupils to work out the same set of experiments and write these up independently, using directions from a manual, is another fruitful cause for formal and mechanical work, in which there may be little motive or real thought, and in which results are little understood. In the usual laboratory directions, the student is often asked the question, "Why?"—when he has altogether inadequate data for an intelligent answer. He is thus forced to guess, or to go to some text or other source of information from which he copies the answer. Nothing is more common in connection with laboratory work than for pupils to write up something suggested in the directions, that did not actually occur at all, and was therefore not observed. It is put in simply because the student thinks he is supposed to see it. This has been especially the case where pupils have been asked to work out minute problems of structure in plants and animals by the use of a delicate microscope which they have little skill in manipulating or interpreting. The same has also been true of much laboratory work in chemistry and physics.

V. Pedagogy of the Present Plan.

The current plan of laboratory work rests in part upon perfectly correct pedagogy. However, a very faulty pedagogy lies at the basis of the weaknesses to which reference has been made. The great purpose for which the laboratory method was introduced is to provide adequate experience and objective illustration for an understanding and appreciation of the laws and principles of a science, and, further, to give an understanding of the application of these to common processes and phenomena. That the laboratory method has realized much of this purpose, no well-informed person can doubt. The poor pedagogy lies in the fact that the current method which is supposed especially to develop a power and habit of scientific thinking has overlooked to a large degree the necessary conditions of reflective thinking. What are these conditions? McMurry has said, and many others have expressed the same idea, that the beginning of any good thinking is a *problem* in the pupil's mind which to him is worth while. The first conditions for thinking are, then, a problem and a motive. These problems grow up, as Dewey has pointed out, from the experiences and situations of life. The trouble with the

laboratory manual method is that the problem of an experiment is made by the teacher or specialist and imposed upon the pupil. Either the pupil does not see the problem at all, and therefore goes blindly to work to follow directions, or if he does see the problem, he sees no connection with his own experiences, and therefore has no motive, unless an artificial one, for working the experiment.

Again, the next step in any good thinking, after having a problem and a motive for trying to solve it, is to begin to think out a method of working it. The laboratory manual wholly deprives the student of this step, and not only imposes the problem upon him and depends largely upon an artificial motive, but it imposes also a complete method for the solution. Thus all the stimuli to good thinking are lacking, aside from the occasional "Why?" thrown into the directions, for the answer of which the student has scant data. Is it strange that under these conditions the conclusions arrived at in experiments are often formal and artificial, and that the work fails to develop a power of independent thought or a vital interest in the subject? That the manipulations themselves are interesting to some pupils and that they develop some skill which may have some value, probably no one would deny. But these values are insignificant compared with the great benefits usually claimed for science work.

VI. Improvement of Present Methods.

What is needed to correct these weaknesses is better *laboratory teaching* and less turning of students loose in the laboratory to work out tasks imposed from without. There should be more use of the laboratory for working out problems which have been formulated by the pupils themselves out of their own experiences, under the guidance of a teacher who has an understanding of what problems are useful in developing the principles of the science, and in organizing these about some central, unifying idea. This can best be done by first organizing the pupils as a class about tables or in the laboratory, with material for observation or experiment ready at hand. Then the teacher begins to question the class concerning their previous experiences along the line of the topic for the day. Natural situations and common experiences are brought before the class, and out of these the teacher by skillful questioning will lead the pupils to formulate many problems which are full of vital interest to the pupils because they are the outgrowth of actual experience. A skillful teacher will

even seek for those things which especially interest pupils by such questions as this—"What things are there in the line of this topic which you would like to find out?"

When these problems have been raised and interest has been stimulated, then the next step is to select certain problems, and by further questioning lead the pupils to work out a method of solving these problems. Of course, pupils can not be allowed to waste time in trying out every line of their suggestions, but by wise direction on the part of the teacher, pupils are led to see the defects in their suggestions, and a workable method is finally agreed upon. Some of these questions may be best worked out by observations or simple experiments at home, or by a visit to some shop or factory, but certain ones will readily adapt themselves to laboratory manipulations. Sometimes the whole class may work the same experiment, but, in many cases, different individuals or different groups may work different experiments. After the work has progressed to a stage where a convenient unit of work has been completed, the class may be called together for further discussion to find out whether work has been properly done and whether good thinking has accompanied it. After full discussion, some things may profitably be put into good form in a notebook and perhaps some sketches made. In some subjects, the field trip will furnish the most effective means of providing experience at a certain stage. This should be conducted with the idea of making it a teaching exercise on the same plan as already outlined.

When a convenient amount of laboratory work has been rounded up in this way, then a textbook lesson may be assigned in connection with a review of all the laboratory work. The text furnishes fuller authoritative information, and helps the pupil to organize all his knowledge about certain principles and more general ideas. In the next class period, the teacher helps pupils in this organization by questions which stimulate further thought. At the same time, the pupils can be held for knowledge gained from the book. Still further, wider understanding can be developed, and practical applications can be made. In this exercise, when ideas have been fully worked out and are clearly understood, technical names, whenever needed, may be presented, and the teacher may assist pupils in forming a close association between these ideas or structures and the terms which are applied to them. Finally, definitions may be formulated and formulas worked out, provided these are not too technical. It will be ob-

served here that definitions and formal statements are the final and not the first step in organizing and rounding up a topic. By far the most common method of recitation observed in classrooms is the exact reverse of that outlined here, that is, definitions and abstract statements are called for at the beginning instead of at the end. After these are stated by pupils, the teacher then asks to have them illustrated by concrete examples. It will be apparent that this common method compels the pupil at once to fall back upon his memory of what the book said. A further step in the complete program should consist of review and summary in which good organization of knowledge is insisted upon, and in which adequate practice and drill are given to enable pupils to gain as large a mastery as possible of the material.

A final step in rounding up any topic may consist of the assignment of special supplementary topics which call for more extended study of available sources of information, along the line of the most practical phases of the subject. These assignments furnish one of the very best opportunities to adapt the work to the varying interests and capacities of the students of the class. For this reason, the teacher should aim to let each pupil select topics along the line of his leading interests. Furthermore, many of these topics will be suggested by problems which have been raised in the class discussion.

It may seem that we have here gone beyond our original topic, viz., "Laboratory Teaching," and have covered the entire field of methods of science teaching. This may be so, but I have done so merely because I believe that the laboratory work when efficiently done is an inseparable part of the complete method and cannot be treated wholly by itself. It may be that in any class exercise, questions and problems may come up which should be referred back to the laboratory for further experiment. Furthermore, I am convinced that much demonstration by the teacher or by groups of pupils is the most desirable plan of answering questions or clearing up knowledge at certain stages of the work. It is understood, of course, that the plan here presented does not apply in any fixed way to any particular recitation or exercise, nor should it be applied in any rigid way to any particular topic. Nevertheless, it does represent a method of procedure which is vital in arousing and maintaining interest, and in securing effective results. That these needs of laboratory teaching are being more and more appreciated is indicated by the statements of many of the recent writers on educational questions. Parker has

recently written as follows: "The laboratory teacher should be especially skilled in *making suggestions and asking questions. He should be present and actually instructing individuals all the time.* We need the same corrective *for unsupervised, undirected laboratory work* as is involved in the stubstitution of *supervised study for home study.* The same type of skill in teaching is required for the proper supervision of laboratory work as for the supervision of individuals who are studying."

A quotation from Professor Mann on the teaching of physics points in the same direction. He says: "It is generally better to introduce a topic by means of informal discussion with the class concerning familiar experiences. For example, if the topic is specific gravity, the knowledge already in the possession of the class should first be called forth by means of questions concerning their experiences with floating and sinking of such familiar things as their own bodies, chips, corks, logs, cream, ice, stones, nails, lead keels, fishing sinkers, etc.

When the principle or idea under discussion has been brought out by such discussion, it should be defined or demonstrated by one or more experiments, and then fixed by requiring the solution of a number of simple, real, concrete problems. If the class work has been skillfully conducted, a number of problems or disputes will have arisen of a sort that can be settled only by making experiments and measurements."

Many other such statements are coming from other authoritative sources. To be convinced that these suggestions have not been at all generally worked out in the practice of the laboratories of the country, one needs but to spend a short time in visiting science work as it is carried on in the average high school. Furthermore, it has been a matter of frequent comment among those visiting high schools that the larger and better equipped schools often show these weaknesses in the laboratory work, to a greater degree than the smaller schools.

HOT ROCKS.

Erosion proceeds with considerable rapidity in the desert region of the Southwest, notwithstanding the scarcity of continuously running water, for rock disintegration is accelerated by the great daily variations in temperature. The rocks are heated to 125° or higher on the hot summer days and cool off rapidly at night to 70° or less, a difference of 50° or more; and in spring or autumn, when the sun's heat is less, the night temperatures are relatively lower.—*U. S. Geological Survey.*

THE PHYSIOLOGY OF HIBERNATION AND SOME KINDRED PROBLEMS.

By W. M. SMALLWOOD.
Syracuse University.

(*An Abstract.*)

When as a boy I learned that woodchucks slept for the winter, going without food during the entire time, I was curious to know how they could do it. Some thirty years passed by before science was able to offer a satisfactory answer to my boyhood enquiry.

To properly understand the physiology of hibernation, emaciation, starvation and the source of metabolic water during hibernation, one needs to keep in mind the modern story of the changes in the food as it gradually and inevitably is transformed into living protoplasm.

The complex foods eaten by animals are greatly simplified in the digestive canal as they come in contact with the several ferments or enzymes. The older term, ferment, from *ferveri*, to boil up, is at present being set aside for the more technical word, enzyme. Whatever term is used for these peculiar substances is unimportant. They are able to act apart from the gland or cell which produces them. Each enzyme is specific in its action. After the digestive enzymes have simplified the several foods, they probably are of little further use to the living organism that produced them. It is believed that the larger amount of the several digestive enzymes passes off with the undigested residue. This is cited as one of the economical wastes in the living body.

After the food has been digested, it passes through the inner membrane of the intestinal wall into the blood. While the food is circulating in the blood, it is in a chemical form quite distinct from that of the digestive canal, even after digestion is completed. Just what the agents are that cause these changes we do not fully understand at present.

This naturally brings us to refer briefly to one of the brilliant discoveries of modern physiology. I refer to the discovery of the internal secretions. We now believe that no set of cells is free from the production of its own internal enzyme. These internal enzymes serve to make the combinations of the nitrogenous and nonnitrogenous food molecules more and more like those that exist in the living protoplasm. This does not mean that we know exactly the molecular composition of living protoplasm, but rather that some of the more elementary relations are

being comprehended. The action, then, of the internal enzymes is just the reverse of the digestive enzymes.

With this brief resume, we may now come directly to our problem. During hibernation, the muscle tissues are the ones that become lighter in weight. The muscle is largely protein with more or less of fat intercolated between the fibers. Hence there must be some agent that circulates in the blood that acts in a manner distinct or characteristic for this period. For during the summer and early fall, the muscles are becoming heavier.

Without going into the historical development of the series of remarkable experiments and researches associated with this problem, we may say that the general conclusion is that the internal enzymes act like digestive enzymes with the result that the protein and fat in the muscle are torn from their summer relation and set free to be used in that part of the body demanding energy. This action of the part of the enzymes is described as the reversibility of enzyme action.

I may illustrate their similar action in starvation by a personal experiment that was tried on Amia calva, the bow fin, an inedible fish that is common in the Great Lakes. The experiment started accidentally when one year I had a few live fish left over as the class finished studying this phase of the course. They were simply left in the basement aquarium in a tank of running water and without food. On my return in the fall, there were a number of the fish alive. This suggested a number of problems that have not yet been completely worked out. From time to time, unfed specimens were killed and their tissues examined. There was no difficulty in keeping Amia a year without food, and one was kept twenty months During this long period of enforced fasting, the fish were at all times active and swam freely. The main external change was a great reduction in the muscle tissue of the tail and back regions. When the muscles were studied in detail, it was found that the cell walls of many of the individual fibers were entirely empty, while adjacent to these empty cells were complete and partly complete muscle cells.

A chemical examination of the normal and starved fish showed the same general proportions of the proteins in each. Nor did a chemical analysis of the blood of normal and starved animals show any marked differences in composition.

The explanation is the same as in hibernation. The fact that some of the muscle cells were destroyed does not change the method by means of which they were broken down. Here there

was a severe drain for the necessary energy to keep the body alive.

These two phenomena make it easy to understand how the human body can lose so much weight in a few days when suffering from a high fever. Here the body is taking no food and is utilizing an unusually large amount of energy. The energy that causes the high body temperature must come from some material substance. It does not come from the food as none is taken to speak of. There is a stress and high tension throughout the body. In imagination, we can picture these unknown chemical bodies, the internal enzymes, running hither and thither searching for more fuel to burn. There is an abundance of it in the fat of the body. This is seized first as the most readily accessible supply. If the demand continues after the fat is gone, the protein in the muscle is torn down to furnish the necessary vital energy. Truly, modern physiology has become as interesting as a story.

Intimately associated with food energy for hibernation is the source of the metabolic water. I believe that it may be safely assumed that the hibernating animal takes neither food nor water. We know how necessary water is to the living protoplasm. Where does it come from? The necessary metabolic water comes from the same source that it does during the active summer life of hibernating animals. As the carbohydrates and in part the proteins are finally utilized, one of the by-products of the splitting up or off process is water which is then taken into the living protoplasm. The usual water drunk is utilized to carry off wastes rather than to enter into the living relation.

MAKING AN ARTESIAN WELL PUMP ITSELF.

The field men of the United States Geological Survey, in their investigations of the ground-water resources of the Virginia Coastal Plain, have observed that the flows from many artesian wells in that region are utilized to drive hydraulic rams for the purpose of lifting the water to higher levels. Along the lower courses of the Potomac and Rappahannock and along the shores of the many inlets that run back from Chesapeake Bay above the James, there are hundreds of artesian wells that supply a perennial flow of beautifully clear water which is, as a rule, excellently adapted to all domestic uses and is largely utilized by the canning factories and other industrial establishments that abound in that part of the country. Though the pressure of the water from the wells is ample at the shore level, the head diminishes so quickly with increase in elevation that no flow can be obtained along the higher banks above the shores where the water is most needed. One method of obtaining it at these higher levels is to use the force developed by the artesian flow to operate hydraulic rams, which in turn raise the water to the heights desired along the bluffs above the river and inlets. Thus it may be said that the artesian wells pump themselves.—*U. S. Geological Survey Bulletin.*

VITALIZING PHYSIOLOGY.[1]

By N. M. Grier,
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Vitalizing the teaching of physiology consists in treating the subject in such a manner as to arouse and retain the student's interest, to relate it to everyday life, and to show him it is worth while. Presentation, perhaps, plays the largest part. Too often the attitude of the instructor is "formal rather than suggestive, negative rather than positive; the appeal is to fear rather than to cheer," and no attempt is made to organize the subject around the more pleasant experiences of the student. Physiology, too, is peculiar in that it is to some extent repetition of instruction already received in the grades.

A new method of approach is desirable, one in which this previous knowledge may be utilized. Such a method is what may be termed the problem method, which would place the divisions of the subject before the students in the form of problems to solve, about which the students may inform the instructor, and the approach to which is secured by arousing the students' curiosity concerning some unfamiliar aspect of them. To this end, every demonstration or experiment and all laboratory work should be utilized as more tangible evidence of the unusual, and, therefore, rendered as striking as possible. The wide-awake teacher will find many classroom incidents of service here, but he must carefully guide the development of the discussion toward the level of everyday life, lest it seem to the students that physiology deals with objects remote from the ordinary.

It is probably true that if a student may be daily made to feel that he acquires something in class of which he knew nothing before, that he will begin to believe his efforts are worth while, and will more vigorously strive to improve. One of the advantages of using the method just described is that the teacher finds excellent opportunity for imparting knowledge of the kind not found in the textbook. A large and profitable source is the data of comparative anatomy and comparative physiology. For example, the frog has no pure blood in his body because he has but one ventricle to his heart; therefore, the necessity of two ventricles for perfect oxygenation of the blood. Again, the slug protects its soft body from laceration by spreading mucus upon

[1]Extract from paper read at conference of St. Louis Association of Science and Mathematics Teachers, April 27, 1916.

the ground on which it crawls; the human animal covers food with mucus, and swallows it more easily. Therefore, mucus has a function as a lubricant.

When encouraged, students readily bring in newspaper clippings whose relation to the divisions of the subject is profitably pointed out. Since, at this age, they are not very apt to take the hygienic precautions set forth by the textbook or instructor in the classroom as applying to themselves, from time to time it may be well to call their attention to the excellent health articles to be found in the daily newspapers, or to the pure food and hygiene departments of some of the more widely circulated magazines which they may have in their homes, and in which they may secure practical information up to the minute. Certain phases of the subject, too, may be made the basis of a special program. On a day designated as "Patent Medicine Day," the students are asked to bring in patent medicine containers of all sorts, when discussion freely takes place, since many of these remedies are advertised in reputable newspapers. They are then instructed as to the effects of the drugs these contain. In the study of ventilation, the classes inspect the ventilation system of the building; while in the study of bacteria, there is described to them the conditions under which the milk they drink in the school lunch room is produced. In short, the attempt is to suggest to the students that physiology is too important and universal to be confined to textbooks.

It may be said that a procedure conforming to that already outlined takes time. But physiology must also answer the increasing demand for the practical, and time so spent, rather than in drills in which anatomical detail and technical terminology play a large part, is more profitable. Concerning these latter two, their problem, it appears to the writer, may be readily solved by the teacher formulating a list of terms, which the cultural values derived from the science would indicate worth while knowing, and abolishing the rest. In what other ways may time be saved to devote to live things? There is apparently no good reason why botany and physiology teachers, or the teachers of any other preceding science, should not agree upon some common form of notebook keeping, grading, correcting, etc., so that no time and energy may be spent by the pupil in acquiring and keeping a new routine. Also recent evidence indicates that increasing ability to draw in the laboratory does not indicate increasing ability in the subject, and that only analytical drawings are of aid to the

student in increasing his knowledge. It is evident a large amount of time may be saved here, but on the other hand, if the calibre of the student's recitations permit it, it is decidedly advantageous to permit combinations of physiology with other subjects taken by him. For example, commercial students may be permitted to recopy their notes by typewriting if they wish, or an art student may be permitted to draw in perspective.

Undoubtedly, the greatest factor in the vitalizing process is the teacher, who can be scarcely said to *teach*, unless he makes his subject alive, when no practical end is immediately evident to the student. Yet any suggestions toward vitalizing may be useless, if there is not back of the attempt a personality attractive to students. To learn to see things the way students do will require cultivation of them and the winning of their confidence. "Some stories, few don'ts and high hopes" rarely fail their purpose and the rest seems readily summarized in Huxley's words of forty years ago:

"Instruction should be real, based on observation, eked out by good explanatory diagrams and models, and not merely catechismal parrot work," and "the hygienist and physiologist should find something in the public mind to which they can appeal, some little stock of universally acknowledged truths to serve as a foundation for their warnings."

ADDITIONAL ILLUSTRATIVE MATERIAL.

See SCHOOL SCIENCE AND MATHEMATICS, *Vol. 15, No. 6.*

1. Metropolitan Life Insurance Co., N. Y. City. Pamphlets on *Occupational Hygiene* and *Science and Public Health.*

2. Sanitol Educational Association, St. Louis, Mo. Charts illustrating formation and time of appearance of teeth.

3. Colgate and Co., N. Y. City, N. Y. Pamphlets on *Dental Hygiene;* pledge cards for care of teeth; charts illustrating diseased and sound teeth.

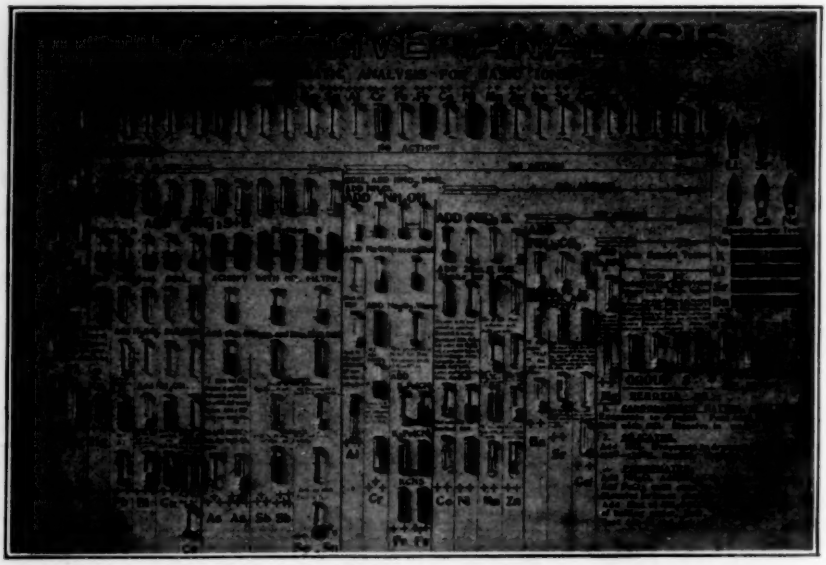
4. Articles on "Pure Food" and "Hygiene" in *Good Housekeeping Magazine.*

5. *The Tongue,* Reed and Carnrick, Jersey City, N. J.

VISUALIZING QUALITATIVE CHEMISTRY.

By C. W. Gray,
Hollywood Junior College, Hollywood, Cal.

Each year in qualitative chemistry, the students are required to make a special report before the class on a subject chosen from a list furnished by the instructor. Last year, one of the students asked permission to make a chart, in place of a report, to show the separation of the metals by means of test tubes fastened to a chart. The accompanying charts are the result. He was greatly bothered by mistakes made by students from other departments assisting him, who had no knowledge of qualitative chemistry. Great ingenuity was shown in changing his separations in order to prevent their mistakes from ruining the chart.



The charts have proved to be a great success.[1] It puts the separations of the metals before the student in a manner that is easily understood and which will not be quickly forgotten. By elimination, the acid chart will assist the student in running down the average unknown much quicker than by the printed outlines.

They are of great value in lectures and recitations since they not only give the separations and the colors of the precipitates

[1] Those interested in the use of the Hollywood Models and Charts in teaching chemistry can obtain from the Braun Corporation of Los Angeles, or the Braun-Knecht-Heiman of San Francisco their descriptive bulletin E 105.

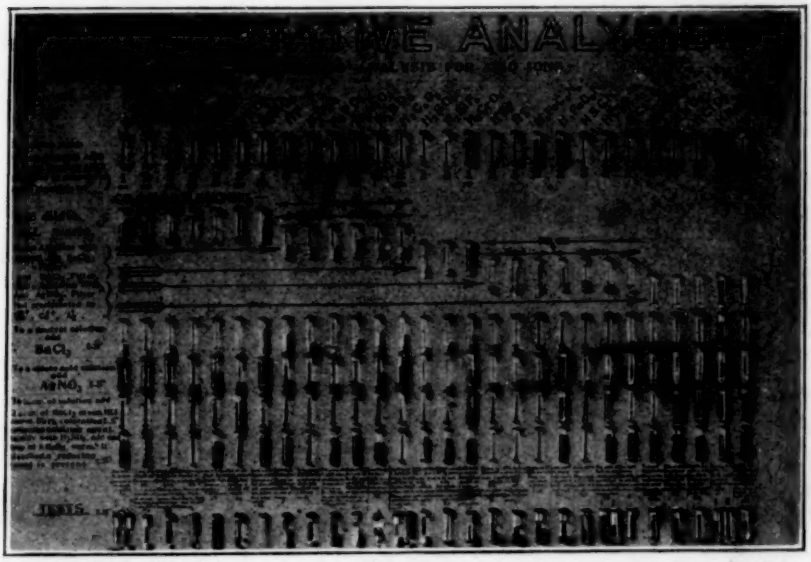
and solutions, but they also give the student a broad view of the whole field as no ordinary printed chart could.

The students use the chart to quite an extent as a reference to refresh their minds as to the exact color and general appearance of various precipitates and solutions.

One of its greatest values came in an unexpected way. The students in general chemistry had the chart before them daily, and it excited their curiosity and in time developed their interest to such an extent that the enrollment in the following year's class in qualitative analysis took an unexpected jump.

It was a little surprising to find how beautiful the charts were when finished. We seldom look at the brilliantly colored precipitates and solutions from the artist's standpoint but usually from that of the chemist's.

As some of the tests were not permanent, it was necessary to



reproduce them in a manner that was permanent and yet realistic. The silver arsenate chocolate brown ring and the brown ring of the nitric acid test were painted on a thin cork inserted in the test tubes. As the water in the test tubes slowly evaporates and in about one year they have to be filled up again, distilled water was used for all colorless solutions, so that on evaporation there is nothing to crystallize out.

From experience in making these charts, we found it best to block out the entire chart very carefully before beginning work

on it. We used the old style beaverboard with its cream-colored surface for the chart. Rubber stamps and black ink were used for lettering the acid chart. The test tubes were wired on with Number 22 copper or German silver wire. One-half-inch by three-inch test tubes were used. The corks were cut about three-sixteenths inch long and paraffined. For the spectrum, a continuous spectrum was painted and part blocked out, leaving the lines desired. A large quantity of the precipitate was made up and allowed to settle, the solution decanted, and the precipitate poured into the small test tube, filling it to one-half inch of the top. Usually, it settled to one-third or one-half test tube full.

Following out this idea, the students in high school chemistry who made a report last year on patent medicines collected a large quantity of headache and cold remedies, and pasted them on a chart. Red arrows were cut out and pasted on, pointing to the fine print giving the composition of the powder. In this way, there can be no complaint made by the manufacturer as we accept his own formula. A typewritten statement of what acetanilide is, its dose, its use, its abuse, etc. (all taken from national author-

ities), is pasted on the center of the chart. Below it, an ordinary loose leaf notebook clasp holds several pages devoted to the claims put forth by the manufacturers for their powders, and statements by Dr. Wiley and others about those powders.

This chart attracts a great deal of attention and is carefully read. It is well worth while in this day and age when the public is using large quantities of such remedies.

VIBRATION FREQUENCY WITH A MOTOR ROTATOR.

By M. L. Fluckey,
Lincoln High School, Los Angeles.

Many may not have tried this simple experiment, which in our laboratory gave as good results as those obtained from the ordinary vibrograph, and is equally obvious.

A motor rotator with a siren disc attached was timed, a minute at a time, for several minutes, and was found to be quite constant in speed. A cyclometer on the instrument gave the number of revolutions, but a separate speed indicator might be substituted. As an example, 1,000 revolutions took 83.3 seconds. The sound was produced by a jet of air against a 48-hole circle on the siren, giving 576.2 vibrations per second for the sound.

This sound was found to be in unison with 27.1 cm. of wire on a somometer. The law of lengths and pitches being assumed, or worked out if desired, the length of wire corresponding to any frequency may be computed easily, or the frequency of any sound computed. A C_2 fork gave a length of 29.8 cm., corresponding to 524 vibrations, instead of a rated 512. This was about the average of accuracy.

The same fork was also tested for wave length by the usual resonance method. The wave length at 20°C. was found to be 70.4 cm. Multiplying by the frequency of the fork, either observed or rated, gave a resulting velocity for sound a little in excess of the usual value given for that temperature. We were especially interested in this latter fact, as measurements taken here by different classes, at different times of year and by totally different methods—using echoes, gunshots, etc.—have given, invariably, results too large, though we tried to eliminate personal errors, and checked watches, tested distances by transits, etc. Does a second hesitate in California?

SEARCH FOR FIREPROOF MATERIAL FOR DECK CONSTRUCTION.

The Bureau of Standards, Department of Commerce, in connection with a general study of fire-resisting materials is considering among other phases of the subject the development of a fire-resisting material for use in constructing, in whole or part, the deck structures of excursion and passenger steamers. So far as may be applicable, the material when developed would also be considered in relation with other marine uses.

The Bureau of Standards would be glad to receive from manufacturers samples of such materials as they consider suitable for the purpose, in order that they may be given consideration.—*Bureau of Standards.*

THE METHOD OF LIMITS IN PHYSICS.

By G. B. Blair,
Oregon Agricultural College.

Certain formulas used in physics may be derived by geometrical methods only by the introduction of the method of limits. The writer has observed that, in these derivations, with possible rare exceptions, the authors of textbooks on elementary physics fail to make clear to the student that the methods used are perfectly rigorous mathematically, and that the formulas obtained are exactly and accurately true, and not merely approximate expressions.

A case in point is the derivation of the equation for the acceleration in uniform circular motion. If a body is moving with uniform velocity in a circular path, a constant force must act upon it, the direction of the force being always toward the center of the path. Whenever a force acts so as to change the velocity of a body, an acceleration is produced in the same direction as that of the force which produces it. In this case, the acceleration is equal to $\frac{v^2}{r}$, where v is the velocity of the body in its path and r is the radius of the path. A fair example of the way in which this expression for the central acceleration is usually derived is given in the following paragraph.

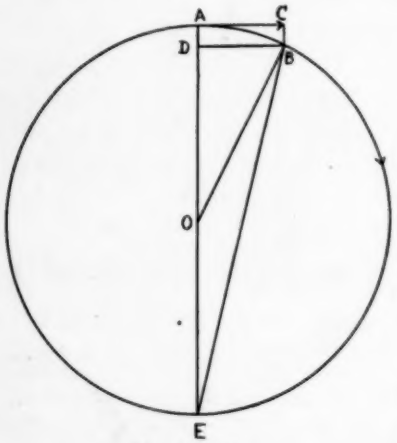


FIGURE I.

"The fact that the acceleration given by the central force is $\frac{v^2}{r}$ can be obtained from a consideration of Figure 1. Suppose a body of mass M to be moving around the circle whose center is O, with a uniform velocity, v. The space AB, over which it passes in the time t, is $S = vt$. Let the time t be taken as a very short time—so short that the arc AB is practically equal to the chord AB. On AB as a diagonal, complete the rectangle, ADBC. The distance the body is drawn away from AC toward O, by the constant centripetal force, is practically equal to

$$\overline{CB} = AD = \tfrac{1}{2}at^2.$$

Now, by geomtery, $\overline{AB}^2 = AD \times AE,$

or $v^2t^2 = \tfrac{1}{2}at^2 \times 2r.$

Hence $v^2 = ar,$ and $a = \frac{v^2}{r}.$ (1)

Observe that the author of the proof given above leads the student to believe that the result that he obtains is an approximate one. He says, "Let the time t be taken as a very short time —so short that the arc AB is *practically* equal to the chord AB," and again, "The distance which the body is drawn away from AC is *practically* equal to CB." It is not wonderful that the student feels dissatisfied with a proof like this. He can see no essential difference between the argument here and that used to demonstrate that the complete period of the pendulum is expressed by the equation,

$$T = 2\pi\sqrt{\frac{l}{g}} \qquad (2)$$

Where l is the length of the pendulum and g is the acceleration of gravity.

As a matter of fact, equation (1) is exactly true, while (2) is only a close approximation to the truth. The following proof, while not rigorously mathematical in the terms used, attempts to lead the student to see that the acceleration at the point A is accurately, and not approximately, $\frac{v^2}{r}$.

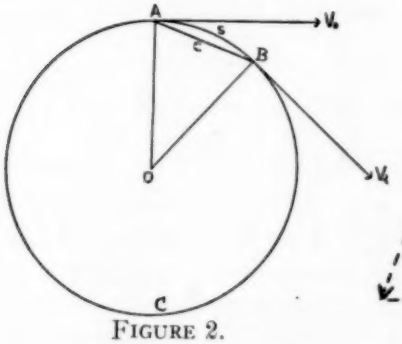


FIGURE 2.

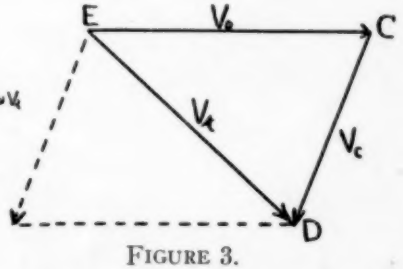


FIGURE 3.

A body moving with uniform speed in the circular path ABCA, Figure 2, moves from A to B in t seconds. The velocity of the body at point A is represented, in both magnitude and direction, by the line V_0; also, the velocity at the point B is fully represented by the line Vt. The only change in velocity which takes place in the time t is a change in the *direction* of the ve-

locity, for the *magnitude* (speed in the path), is the same at B as it is at A.

Fig. 3 shows that V_t may be obtained by combining with V_0 another velocity, V_c; *i. e.*, the velocity V_c, added to the velocity V_0, changes the direction of the resulting velocity without changing its magnitude. V_c is therefore the change in velocity in t seconds.

Since V_0 in Figure 3 is perpendicular to AO in Figure 2, and V_t in Figure 3 is perpendicular to OB in Figure 2. the triangles ABO and CDE are similar and

$$\frac{V_c}{C}=\frac{V_0}{r} \text{ or } \frac{\text{Change in velocity}}{\text{Chord C}}=\frac{\text{Velocity at A}}{\text{Radius}}. \quad (3)$$

It is clear that the velocity of the body is continually changing, and, since this change is a steady one, the rate at which the change takes place is the same for all points in the circular path. If the point B is taken very near to the point A, the chord C and the arc S will be very nearly equal in length, and, with very small error, S may be written in place of C. Equation (3) then becomes $\frac{V_c}{S}=\frac{V_0}{r}$ (approximately). (4)

But S is the distance which the body travels in the very short interval of time, t, and the speed in the path is constant so that $S=V_0t$.

Substituting in (4),

$$\frac{V_c}{V_0 t}=\frac{V_0}{r} \text{ or } \frac{V_c}{t}=\frac{V_0^2}{r} \quad \text{(approximately)}. \quad (5)$$

But the change in velocity in time t, divided by t, gives the velocity change per unit time, *i. e.*, the acceleration.

Therefore, the acceleration at $A=\frac{V_0^2}{r}$ (approximately) (6).

But it is possible to make t as small as we like, thus bringing B nearer to A, and causing the chord C to differ as little as we please from the arc S. Thus, as the change in velocity, V_c, is expressed for a portion of the path less and less distant from the point A, expression (6) becomes more and more accurately true, and we are led to the conclusion that the acceleration at the point A is given exactly by the expression,

$$a=\frac{V_0^2}{r} \quad (7)$$

Where a is the acceleration, V^0 is the velocity in the circle, and r is the radius of the circle.

The student, in his study of electricity, meets with another case where he is asked to believe that the application of an assumption, not shown to be more than a mere approximation, leads to a perfectly exact result. The usual method of proof that the electrical potential at a distance r from a charge Q is expressed by the equation $V = \frac{Q}{d}$ involves an application of the method of limits.

The force acting on a unit charge at a point P_1 at a distance d_1 from Q is $\frac{Q}{d_1^2}$; the force acting on a unit charge at P_2 at a distance d_2 from Q is $\frac{Q}{d_2^2}$. The statement is made that if P_1 and P_2 are very near together, the average value of the force acting on a unit charge as it moves from one point to the other will be very nearly equal to the geometrical mean between the two quantities, namely, $\frac{Q}{d_1 d_2}$. The validity of the proof rests upon the assumption that, in the limit, when P_2 is indefinitely close to P_1, the expression $\frac{Q}{d_1 d_2}$ is actually the average force acting on the unit charge, yet the texts that use this form of proof inform the student that it is *very nearly the average force.* Thus, they not only do not justify the assumption made, but do not even clearly state it.

A NEW METHOD FOR THE MEASUREMENT OF THE WAVE LENGTH OF LIGHT WITH A COARSE GRATING.

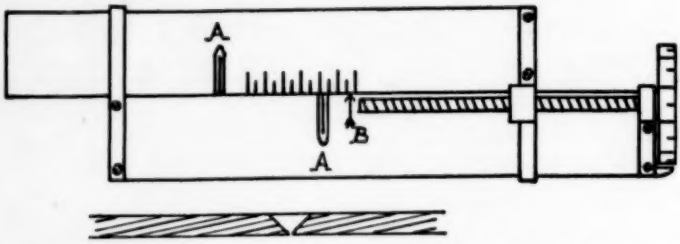
By Will C. Baker,

Queen's University, Kingston, Ont.

The following method has been used with satisfaction in this laboratory during the past few years.

Two rectangular pieces of brass (10x30 cm.) are mounted against one another by means of brass straps that permit the sliding of one along the edge of the other. The amount of this displacement is controlled by a screw of millimetre pitch that is fitted with a head divided into twenty parts, as indicated in the figure. Two slits are cut in the brass as shown at A, A, and a section of one of these is given in the lower part of the sketch. A scale

of millimetres, as indicated, and an index, B, are scratched in the brass, using the screw itself to produce the displacements during this operation.



These slits are mounted, with the screw vertical, in front of a double Bunsen burner, into each flame of which is thrust a bit of ordinary sodium glass quill tubing. The coarse photographic grating (about 10 lines to the mm.) is mounted on a stand a metre or so away, with its lines parallel to the slits. On looking through the grating at the slits, one sees the two direct images, and three or four, sensibly equidistant, diffraction images on each side of the slits. One of these may be used as an index to measure the angle of diffraction of the various orders of spectra. For instance: If the undiffracted image of one slit be brought into line with the first spectrum of the other slit, the angle of diffraction of that spectrum is given very nearly (tan. for the angle itself) by the distance from slit to slit divided by the distance from the slits to the grating. This latter distance, usually between one and two metres, is most conveniently measured by sliding one metre stick over another until the ends just touch the slits and the grating; the distance is then easily read off.

In practice, it is found best to set the slits at some distance a little under a centimetre and to make the adjustment required by moving the grating to or from the slits until the spectra are in line with one another. Usually, the distance from slit to slit, as read from scale and screw head, is divided by the mean of four or five readings of the distance from slits to grating (each being from a different setting of the grating).

The distance between the slits is now approximately doubled, and a series of settings made in which the undiffracted image of one slit is brought into line with the *second* spectrum of the other slit. For the *third* spectrum, the slits are moved to about three times the original distance, and so on for the other spectra.

There need never be any confusion as to the order of the spectrum worked with, for if the observer but move his eye to one side, so as to look past the ends of the lines on the grating, all but the undiffracted images disappear; then in slowly moving his head back again the number of spectra between may be seen at a glance.

The object of using a coarse grating for junior students is primarily to permit them to measure its spacing with a low power traveling microscope. Usually, the distance over 20 or 30 lines is read in different parts of the grating. The coarse grating has, however, another advantage in this case as it gives small angular separation of the spectra, not only giving a series for the student to measure, but, as they are so nearly equidistant, that from n spectra on each side of a slit one can obtain measures for spectra as high as the $2n$th, *i. e.*, by obtaining the angle that brings the nth spectrum *below* one slit into line with the nth spectrum *above* the other. A set of typical measurements is given below from a case where only three spectra were visible on each side of the slits.

Distance across 20 lines (by traveling microscope), 0.204 cm. Therefore $a = 1.02 \times 10^{-2}$ cm.

$$\lambda = \frac{a \sin\theta}{n} = \frac{a\,d}{n\,D}.$$

Distance Slit to Slit. d cm	Distance Slit to Grating. D cm.	Order of Spectrum. n	Wave Length Found in Centimetres. λ
1.019	168		
	172		
	171		
	mean 170	1	6.12×10^{-5}
1.954	169		
	168		
	167		
	mean 168	2	$5.95 \times$
2.835	161		
	162		
	163		
	mean 162	3	$5.95 \times$
3.632	157		
	156		
	158		
	mean 157	4	$5.92 \times$
4.348	189	4	$5.86 \times$
5.542	193	5	$5.86 \times$
6.242	180	6	5.94
		Mean 5.94	$\times 10^{-5}$

GENERAL SCIENCE—ITS CHARACTER.

By HELEN B. SHRIEVER,

William Penn High School for Girls, Philadelphia, Pa.

Every demonstration rests upon a necessity. The necessity of a general science course is demonstrated by the national advertisers of the country. The Eastman Kodak Companies, the soap companies, the electric companies, the gas companies, the food companies, the manufacturers of household conveniences, and the automobile manufacturers are spending *tremendous* amounts of money to teach the general public to use efficiently and benefit by the products of their researches in the domains of physics, chemistry, biology, engineering, and other divisions and subdivisions of scientific import almost too numerous to think of.

Can one believe that they are so generous as to do this unless their efforts met with an appreciative interest and response? These advertisements are not theses beginning with the ionic theory and ending with push the button, but are psychological demonstrations teaching how to utilize the embodied conclusions of scientific progress for the *benefit* of the *purchaser*.

The necessity for teaching general science rests upon the fact that man does not and cannot create anything. He observes and studies the phenomena of nature, and learns to formulate her laws in order that her prodigal bounty may be utilized for the benefit of mankind.

The necessity of a general science course is also based on the lack of time to study the detailed causes of physical and biological phenomena or the reasons for the formulated rules. The laws, rules, and precepts that have been discovered and formulated by the great physicists, chemists, and biologists can be utilized even though the sequence of the underlying fundamental reasons is unknown. Thousands of people are taught to run automobiles who have no capacity to comprehend the remote sources of power in nature or the transformations of energy.

The pupil should have some knowledge of the tools of nature and also of what can be done with them. The general science course makes this possible. The physical sciences deal with the *forces* of nature as energy, heat and light, while the biological sciences show us the *effect* of these forces on *life*. General science tends to utilize the facts of these sciences for the benefit of man.

The *insistent* why in the minds of some pupils, which has

always been present and always will be, must be satisfied, however, and just as much of this abstract work should be done as time and the ability of the pupils permit.

The wonderful work done by great scientists is available, and one of the duties of general science is to teach an appreciation of these men and their work. Those pupils who show an inclination for delving into causes should be given the opportunity to become students of the physical and biological sciences.

Since general science rests upon a necessity, the purpose of the course is to meet this broad necessity, and the characteristics of the course should be based on the varied needs.

Many science teachers unquestionably would give as the purpose of a general science course—the desire that our young folks acquire a measure of scientific knowledge which they can use in everyday life. How much science these young people acquire depends upon the time allotted to the subject and also upon the year or years in which the subject is given.

At the school of Pedagogy, Thirteenth and Spring Garden Streets, an elementary introductory science course is creditably worked out during the eight years of grade work. These pupils, however, are so small in number that we must say practically all pupils entering high school have had no science work.

Now, these pupils need an elementary course in science to stimulate the process of reasoning—to observe first hand what is happening around them—to start the habit of thinking out answers and to begin to interpret what is seen.

The difficulty in teaching this course is to make it simple enough for the young mind to grasp, and to tie together a number of loose bits of information, observations, and facts obtained by tests and experiments, and to correlate them so as to make them stick and at the same time to build the foundation for the subsequent courses in the physical and biological sciences.

As I have said before, the purpose of a course determines its characteristics. When teaching general science, I have observed that it brings about a natural condition of the pupil toward his work, instead of a forced relation which so often results in languid and purposeless efforts. The reason for this attitude is that the pupil works from the known to the unknown.

Because the things in the world about can only be understood in reference to the intuitive or known conceptions in the pupil's mind, this course results in helping the pupil to correlate his life with the world about him.

It makes toward intelligent rather than learned people in after life. Graduation means the end of book learning for many people. Experience, practice, interest, and association are the only means of learning after that. By bringing about the correlation of the pupil's ideas with the things going on in the world about him, a habit has been established which is not so apt to cease, while any reference work which he may have done in connection with the course will tend to lead him to consult books for authorative information on the subject.

The work in a general course appeals to the pupils. I know that the girls like the work because they can and do go home and repeat some of the experiments that they have done in the laboratory. This shows that they have got something that sticks. While taking the work, they are constantly bringing problems of the home to the teacher to have her help solve them. Applying knowledge practically appeals to old and young alike.

The adaptability of the course is extensive. Local conditions help determine the character of much of the work done in the course. In fact, any particular sections of the country or any marked peculiarity of a locality would determine somewhat the nature of the course. A boys' school would do different work from a girls'. Not only high schools for girls, but even colleges for women, have borrowed the science curricula from boys' schools and men's colleges, and made all the girls do work which was not relative to their interests or tastes.

Any group of boys taking a science course acquires a considerable amount of general science naturally, because boys somehow or other get around in shops, manufacturing plants, and various places where the why is always aroused, and if it is not answered on the spot, ten chances to one it is brought up with the class work either as volunteered information or in the form of questions.

The contrary of this statement is true of the girls. The girl who acquires any general scientific training outside of the school is the rare exception. On account of the great wealth of material for a general science course, boys and girls can have courses best fitted to their needs, and even particular groups of boys and girls can have special attention given them in the planning of their courses, since the purpose of the course determines the character of the work planned.

A course so planned helps to adjust a pupil to his environment, and gives him a broader basis upon which to select his avocation. I think there is need for such a course in the night

schools. It is quite probable that there are more colleges and universities where high school graduates can have the opportunity of specializing in some science than there are high schools where all the boys and girls can have a general science course which will help in the adjustment of the individual to the community.

Among pupils taking this general work, a teacher will always find a few who show the possibilities of doing creditable work in the specialized sciences; sometimes it will be a leaning toward the biological, sometimes toward the physical sciences. A general science course is helpful then in interesting to such a degree the pupils who possess the possibilities of developing into scientists that they continue their work in the specialized sciences.

A teacher of general science needs technical knowledge of the biological and physical sciences as well as practical experience in using this technical knowledge.

Because interest and enthusiasm are contagious, the teacher is willing to give of her time to help individuals who bring special problems. It is the exception for girls not to be able to do the work, and here is one of the strong points of the course, because pupils like the actual doing of things. This is a hopeful aspect for the teacher because she knows she is not up against an impossibility. The relation between teacher and pupil is healthful and stimulating to both. A teacher of a specialized science in changing to general science finds that she has new things to learn and a different point of view to acquire.

General Science—Its Relations to the Physical and Biological Science Courses.

In contradistinction to this *general* course, physics, chemistry, and biology are all specialized courses. The general course is the bread and butter for the pupil who is a pupil for the few years he spends in school. Physics, chemistry, and biology are the specialized articles of diet for the student who is a student from his first day in school until his graduation from the university. It is *all* food, and should be apportioned according to the respective needs. There are specific needs for a physical or biological course for some pupils.

Some of the divisions of the science of biology are botany, zoology, morphology, physiology, hygiene, phychology, sociology, ecology, paleontology, etiology, systematic botany and zoology, and economic botany and zoology. These subdivisions are of varying importance as regards meeting the needs of the pupil. As

the general knowledge of biology implanted by the general course can be applied to human welfare just so are the detailed teachings of biology of importance provided they become of use. I think the same is true of physics and chemistry but I shall leave this question for the chemist and physicist to decide.

The needs of detailed teachings are measured by utility to the pupil and adaptability for assimilation. I believe that just as much of specialized teachings should be given as the pupil can assimilate with benefit. Specialized teaching must have utility as a basic principle at all times.

I have endeavored to show that the teaching of *general* science and of *specialized* science is a question of *relative* necessity measured by utility.

OXIDATION OF AUTOMOBILE CYLINDER OILS.

The Bureau of Standards, Department of Commerce, has just issued a pamphlet, *Technologic Paper, No.* 73, giving certain data relative to the oxidation of automobile cylinder oils which has been made the subject of a recent study by that Bureau.

The rate of oxidation of three oils when exposed to sunlight and air was studied, and the increase in weight, acidity, and carbonization value, as well as changes in the Maumene and iodine numbers and in the demulsibility, were determined. Changes in the carbonization values of these three oils and of eight others, when heated for different lengths of time at a given temperature, and for the same time at different temperatures, were studied.

The bearing of the work of the Bureau upon the testing of oils is pointed out.

Copies of the paper may be secured free of charge by persons interested upon application to the Bureau of Standards, Washington, D. C.

PETROLEUM AS LOCOMOTIVE FUEL.

Figures just made public by the United States Geological Survey disclose a marked increase in the use of petroleum as a locomotive fuel by the railroads of the United States in 1915. The data at hand show that the quantity of oil fuel so consumed last year was 36,648,466 barrels, an increase of 5,555,200 barrels or eighteen per cent over the similar consumption in 1914. This increase is ascribed to the relatively low prices prevailing for fuel grades of oil during the last year and a half as a result of the increased production of low-grade crude in the Gulf Coast States and in Mexico and of the augmented output of suitable residuals from refineries operating in ever-increasing number in Oklahoma and Kansas.

The total distance covered by oil-burning locomotives in 1915 was 124,255,525 miles and the average distance covered per barrel of oil fuel consumed was 3.39 miles. Oil fuel is now used to some extent on forty railroads in the United States, having tracks in twenty-one States.

PROBLEM DEPARTMENT.

By J. O. Hassler,
Englewood High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions. All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. In selecting solutions for publication we consider* accuracy, completeness, *and* brevity *as essential. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

Algebra.

476. *Proposed by F. M. Phillips, Central College, Pella, Iowa.*

A tree 100 feet high, and standing in 12 feet of water, is broken so that the part broken off reaches from the stump to the ground, passing through the surface of the water 15 feet from the stump. Find the height of the stump.

I. *Solution by Norman Anning, Chilliwack, B. C., and R. M. Mathews, Riverside, Cal.*

Let x be the height of the stump above the water. Then $\sqrt{x^2+225}$ is the length of the broken-off part that is above the water.

From similar triangles,

$$\frac{100}{x+12}=\frac{x+\sqrt{x^2+225}}{x}.$$

This yields the cubic equation,

$$8x^3-295x^2+216x+1296 = 0,$$

whence

$$x = 36, \quad 2.60, \quad -1.72.$$

The total length of the stump is 48 or 14.60 feet.

To admit the negative value of x, the problem would have to be differently worded.

477. *Proposed by Norman Anning, Chilliwack, B. C.*

In any scale of notation any multiple of m which has n digits remains a multiple after cyclic permutation of the digits, provided that m is a factor of the number formed by placing n 1's in a row.

Solution by the proposer.

Let the symbol

$$(a, b, c, \ldots k) \equiv ar^{n-1}+br^{n-2}+ \ldots +k.$$

denote a number of n digits in the scale of r.

Assume

$$r^{n-1}+r^{n-2}+ \ldots +r+1 = pm,$$

and

$$(a, b, c, \ldots k) = qm.$$

To test $(b, c, \ldots k, a)$ for divisibility by m:

$$(a, b, c, \ldots k, 0) = qmr,$$

$$(b, c, \ldots k, a) = qmr-a(r-1)pm,$$

$$= \text{a multiple of } m.$$

Since any cyclic permutation can be affected by moving one digit at a time from one end of the number to the other, the above is sufficient to establish the theorem.

Example: Scale of 10.

13279, 32791, 27913, 79132 and 91327 are all multiples of 271.

Trigonometry.

478. *Proposed by R. T. McGregor, Bangor, Calif.*

A circle one foot in diameter is divided into three equal parts by two parallel lines. Find the distance between the parallels.

I. *Solution by Norman Anning, Chilliwack, B. C.*

Let θ be the angle subtended at the center by either of the arcs between the parallel chords. Then a study of areas leads to the equation.

$$\theta+\sin\theta=\frac{\pi}{3}=1.0472.$$

Since θ and $\sin\theta$ are nearly equal, each must be about $\pi/6$. Assume $\theta=\frac{1}{6}\pi+\phi$, where ϕ is so small that ϕ^3 is negligible.

$$\frac{\pi}{6}+\phi+\sin\left(\frac{\pi}{6}+\phi\right)=\frac{\pi}{3},$$

$$\frac{\pi}{6}+\phi+\sin\frac{\pi}{6}+\phi\cos\frac{\pi}{6}=\frac{\pi}{3},$$

$$\phi+\frac{1}{2}+\frac{\phi\sqrt{3}}{2}=\frac{\pi}{6},$$

$$(2+\sqrt{3})\phi=.0472,$$

$$\phi=.01265,$$

$$\frac{\pi}{6}=.5236,$$

$$\theta=.53625 \quad [=30^\circ\ 43\tfrac{1}{2}'].$$

The distance between the parallels

$$=12\sin\theta/2=3.18 \text{ inches}.$$

II. *Solution by Clifford N. Mills, South Dakota State College, Brookings, S. Dak.*

Let AB and CD be the two parallel chords. They must be equally distant from the center of the circle. The area of the segment having AB, or CD, as a base is $1/3\pi r^2$.

Hence,

$$1/3\pi r^2=1/2r^2(\theta-\sin\theta).$$

Therefore,

$$1/3\pi=1/2(\theta-\sin\theta),$$

or

$$\sin\theta=\theta-2\pi/3.$$

Plotting the curves $y=\sin\theta$ and $y=\theta-2\pi/3$, we find $\theta=149^\circ\ 16'$. θ being determined, one readily finds that the chords are at a distance of .1325 foot from the center of the circle, hence the y must be .265 foot, or 3.18 inches, apart.

[We have learned since proposing his problem that one very much like it was proposed and solved as No. 311. Solutions by *H. H. Seidell, W. C. Eells,* and *Nelson L. Roray* may be found on page 72 of Volume XIII (January, 1913).—EDITOR.]

Geometry.

479. *Proposed by Edward Fleischer, Bushwick High School, Brooklyn.*

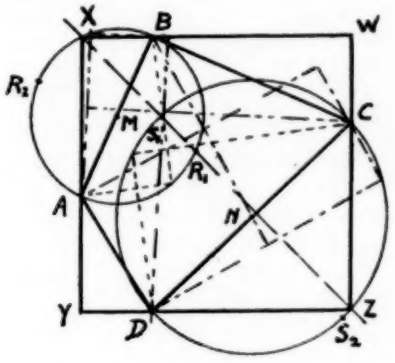
Through four given points pass four lines which shall form a square.

I. *Solution by R. M. Mathews, Riverside, Cal.*

Let A, B, C, D, be the four points in order; join them to form a quadrilateral. On two opposite sides, AB and CD, as diameters, con-

struct the circles, M and N, respectively. On circle M take AR_1 = a quadrant; on circle N take DS_1 = a quadrant. Draw R_1S_1 to cut circle M at X and circle N at Z. Let AX cut DZ at Y and BX cut CZ at W. Then XYZW is a square whose sides pass through the four points—A, B, C, D.

Proof: $\angle BXY$ and $\angle CZD$ are evidently rt. $\angle$s. Further, $\angle S_1ZD = \frac{1}{2}$ rt. $\angle = \angle R_1XY$. Therefore, ΔXYZ is an isosceles right triangle. Therefore, XYZW is a square.



Let R_2 denote the point diametrically opposite R_1 on circle M and, similarly, S_2 for S_1 on circle N. There are four possible diagonal lines, R_1S_1, R_1S_2, R_2S_1, R_2S_2, and so in general we have four distinct squares arising from the use of the circles, M and N.

II. *Solution from Dupuis' "Synthetic Geometry of the Point and Line" (1896), p. 82. Reference made to the Editor by Norman Anning.*

Given the points, A, B, C, D, not in a straight line, to pass through A, B, C, D, four straight lines forming a square.

Join AC. Draw BE = AC and $\perp$ AC. Join DE. Through C and A draw perpendiculars to DE. Through B draw a line parallel to DE. These four lines produced will form a square.

Proof: Draw through E a line perpendicular to DE, cutting the opposite side of the square in F, AG parallel to DE, cutting opposite side in G. In the similar right triangles, BEF, ACG, BE = AC.

$\therefore$ $\Delta BEF \cong \Delta ACG$.

$\therefore$ AG = EF and the figure is seen to be a square.

III. *Remarks by the Editor on the number of squares possible.*

If we consider the possible solutions of the problem, we find that by constructing circles on the opposie sides, BC and AD, as diameters (referring to Mr. Mathews' figure), and on the diagonals, AC and BD, as diameters, we would apparently have twelve possible squares—four for each pair of circles. We can show that these coincide in pairs.

Conforming to the notation of the figure, let M′, N′, M″, N″ be the mid-points, respectively, of AD, BC, AC, BD. Consider the four circles with centers M′, N′, M″, N″. Let $[R'_1, R'_2]$, $[S'_1, S'_2]$, $[R''_1, R''_2]$, $[S'_1, S''_2]$ mark the quadrant points of the circles, M′, N′, M″, N″, respectively, so that R'_1 and BC lie on the same side of AD, S'_1 and AD lie on the same side of BC, R''_1 and B lie on the same side of AC, and S''_1 and A on the same side of BD.

The square, WXYZ, coincides with the square constructed in a similar manner by use of the circles, M′ and N′, and the line, $R'_1S'_1$. (Y and W are on circles M′ and N′, respectively, and WY makes an angle of 45° with the sides. Hence, it must pass through R'_1 and S'_1.)

In a similar manner, the following correspondences may be proved:

$$\begin{aligned} R_1S_2 &- R'_2S'_2, \\ R_2S_1 &- R''_2S''_2, \\ R_1S_2 &- R''_1S''_1, \\ R'_2S'_1 &- R''_1S''_2, \\ R'_1S'_2 &- R''_2S''_1. \end{aligned}$$

Therefore, we have six distinct squares.

480. *Proposed by the Editor. Sequel to No. 465.*

In the angle LOM are situated the fixed points, A and B, such that AO $= a$ and makes an angle α with OL, BO $= b$ and makes an angle β with OM. There is a shortest line from A to B touching both sides of the angle LOM. Find its length and show under what conditions it must touch OL first. Consider all cases for $\angle$LOM $< 180°$. Consider also other methods of constructing path than the one published under No. 465.

Solution by R. M. Mathews, Riverside, Cal.

Let $\theta = \angle$LOM.

Reflect A to A′ around OL, A to A″ around OM.

Reflect B to B′ around OM, B to B″ around OL.

Let A′B′ cut OL in F and OM in G.

Let A′B″ cut OL in Y and OM in X.

Suppose A′B′ $<$ A″B″. Then AFGB is the required path; for it is equal to A′FGB′ $=$ A′B′, which is shorter than any broken path such as AF′G′B; and

$$\overline{A'B'}^2 = a^2+b^2-2ab\cos(\theta+\alpha+\beta).$$

But in case

$$(\theta-\alpha)+(\theta-\beta)+\theta < \theta+\alpha+\beta,$$

that is to say,

$$\theta < \alpha+\beta,$$

then A″B″ $<$ A′B′ and the path is AXYB.

Moreover, when $\theta+\alpha+\beta = 180°$, one of the lines, A′B′ and A′B″, goes through the vertex O, and in case it is the shorter, the path is AOB $= a+b$. This occurs when the other line cuts OL or OM extended through O.

Finally, when both $\theta+\alpha+\beta$ and $3\theta-(\alpha+\beta)$ are greater than a straight angle, the path is AOB; for any path such as AXYB (touching either OL or OM first) is equal to a patht A′XYB′, which it is easy to prove is greater than A′OB′.

CREDIT FOR SOLUTIONS.

476. Norman Anning, Charles L. Brosey, Mabel G. Burdick, W. C. Eells, W. H. Hill, Ralph Jones, M. Helen Kelley, Daniel Kreith (2), L. E. A. Ling, R. W. Lord, R. M. Mathews, Clifford N. Mills, M. T. Nolan, John C. Parlin, F. M. Phillips. (16)

477. Norman Anning.

478. Norman Anning (2), Mabel G. Burdick, William W. Johnson, Daniel Kreith, R. M. Mathews, Clifford N. Mills. (7)

479. Edward Fleischer, E. H. Koch, L. E. A. Ling, R. M. Mathews. (4)

480. R. M. Mathews.

29 solutions.

PROBLEMS FOR SOLUTION.

Algebra.

492. *Proposed by Harry M. Roeser, Washington, D. C.*

Solve

$$x^2+x = y^3+y,$$
$$x^3+x^2 = y^4+y.$$

492. *Proposed by Harry M. Roeser, Washington, D. C.*

The popular game, "shooting craps," is played as follows:

Two players place a stake. "A" throws two dice. If the sum of the spots turned up at the first throw totals 7 or 11, he wins; if they total 2, 3 or 12, he loses. If none of these points are turned, he throws again and again and wins when he duplicates the point that is turned on the first throw. He loses if, while attempting to duplicate his point, the dice turn up 7. Let it be required to demonstrate that the player rolling the dice has or has not an even chance of winning.

Geometry.

493. *Proposed by Norman Anning, Chilliwack, B. C.*

An antiquarian finds a brick, 8 inches long, 2 inches thick at one end, and $1\frac{3}{4}$ inches at the other, and covered uniformly with mortar $\frac{1}{4}$ inch thick. He reasons that it formed part of a semicircular arch. Find the span and number of bricks.

494. *Proposed by R. T. McGregor, Bangor, Cal.*

AB and CD are two parallel chords of a circle and L and M are their mid-points, respectively. BM and DL are produced to meet the circle again in E and F. Prove that the five following points are collinear: The points of intersection of BM and DL, of BC and DA, of FC and EA, of the tangents at A and C, of the tangents at B and D.

495. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

The sides of a trapezoid in order are 3, 5, 10 and 8, respectively, the sides that are parallel being 3 and 10. Find the volume generated by revolving the trapezoid about side 5.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Readers of School Science and Mathematics are invited to propose *questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

234. *Proposed by W. S. Wake, Central High School, St. Louis, Mo.*

Devise and explain an electrical circuit in which there is an *electromotive force* but *no potential difference.*

235. *Proposed by R. W. Boreman, Parkersburg, W. Va.*

A solution of $Mg(OH)_2$ has 0.0009 parts of the $Mg(OH)_2$ in 100 parts of water. What is the maximum concentration of OH ion that can be present in 0.1 molar $MgSO_4$ solution that is 37% ionized?

Please answer questions numbered 236 237, from the following examination paper:

Comprehensive Examination in Chemistry, June, 1916.

Part I. (Answer All Questions in Part I.)

1. Discuss concisely the important classes of compounds—acids, bases, and salts—from the standpoint of—(*a*) their composition, (*b*) their preparation, (*c*) their properties. Illustrate your answer fully with formulas and with equations for reactions.

2. (*a*) Give a concise statement of the constitution of matter according to the atomic theory.

(*b*) State any two laws fundamental to the theory, and show how this theory explains these laws.

3. Write equations for the following reactions, using formulas throughout. The equations must be properly balanced to receive credit:

(*a*) Sodium acid carbonate+hydrochloric acid = ?

(*b*) Calcium phosphate+sulphuric acid (in excess) = ?

(*c*) Copper+nitric acid (dilute) = ?

(*d*) Ferric nitrate+ammonium hydroxide = ?

(*e*) Silica+sodium carbonate (fused) = ?

236. A certain quantity of magnesium dissolved in acid gave exactly 100 cc. of dry hydrogen at a temperature of 22° C. and a pressure of 780 mm. How many grams of metal were used? Compute the result to three significant figures (Mg = 24.3).

NOTE.—A liter of hydrogen at 0° C. and 760 mm. weighs 0.09 gm.

5. Chlorine and nitric acid often act as oxidizing agents, sulphur dioxide and carbon as reducing agents. Explain these statements and give examples, with equations, illustrating these actions. State any necessary conditions of dilution or of temperature.

Part II—Supplementary Requirements—Group A. (Answer Two Questions From This Group.)

6. Give the names and formulas of five common minerals of industrial importance. State what commercial use may be made of each of them.

7. Classify in natural groups the following elements—carbon, calcium, chlorine, barium, bromine, iodine and silicon. Indicate the relations of those within each group by comparing the formulas and the properties of their oxides or hydrides or both.

8. Answer any two of the following questions:

(*a*) Why does a water solution of ferric chloride give an acid reaction, while one of sodium carbonate gives an alkaline reaction?

(*b*) Account for the fact that a solution of common salt in water conducts the electric current, while one of sugar does not.

(*c*) Which exhibits the greater osmotic pressure, a gram-molecular solution of salt or one of cane sugar? Why? Sketch an apparatus for demonstrating osmotic pressure.

9. (*a*) How would you proceed in order to get large crystals from a solution? Small ones?

(*b*) Why do certain crystalline substances on exposure to the air crumble while others do not?

Group B. (Answer One Question From This Group.)

10. At standard temperature and pressure, one liter of the gaseous element, A, unites with three liters of the gaseous element, B, to make two liters of the gas, C. If each molecule of C contains one atom of A, what is the simplest formula for a molecule of the element A? Show clearly how you arrive at your conclusion.

237. One gram of pure iron forms 1.43 gm. of an oxide. Find (*a*) the percentage composition for this oxide of iron, (*b*) its simplest formula, and (*c*) the equivalent weight of iron in the compound. (Fe = 56, O = 16.)

Group C. (Answer Two Questions From This Group.)

12. How would you determine by chemical tests whether (*a*) "woolen" goods contained cotton, (*b*) baking powder contained ammonium compounds, (*c*) water contained chlorides?

13. (*a*) State the composition of two kinds of baking powder.

(*b*) Write an equation for the reaction which occurs when one of these powders is moistened with water.

(*c*) Explain the action of yeast in bread-making.

14. (*a*) Mention two compounds of nitrogen that are used as fertilizers.

(*b*) What natural provision is there for converting the nitrogen of the air into plant food?

(*c*) Outline one artificial process for the fixation of atmospheric nitrogen.

15. Give the method of keeping and the necessary precautions in the storage of each of the following substances: (*a*) sodium, (*b*) gasoline, (*c*) yellow (white) phosphorus, (*d*) bromine, (*e*) hydrofluoric acid.

CHEMISTRY EXAMINATIONS FOR ADMISSION, BOSTON UNIVERSITY, SEPTEMBER, 1916.

Time: One Hour, Thirty Minutes.

1. Name three important products obtained from petroleum. State the properties and uses of each.
2. How is sulphuric acid made? State its properties and uses. How much sulphur can be obtained from a ton of acid which contains two per cent of water? [S = 32, H = 1, O = 16.]
3. How is aluminium prepared? State its properties and uses. What is its approximate price a pound?
4. How can the atomic weight of zinc be found?
5. What is the chemical name and formula of sand, baking soda, quicksilver?
6. How is ammonia prepared in the laboratory? Sketch the apparatus used.
7. What volume of air at 0° C. and 760 mm. (free from water vapor and carbon dioxide) contains one gm. of nitrogen?
8. Write the ionic equation for the neutralization of sodium hydroxide by nitric acid.

NOTE.—Laboratory notebooks submitted at the time of examination must be called for at the Dean's office not later than September 20, 1916.

Solutions and Answers.

225. *From Physics, College Entrance Examination Board, 1915.*

A blow struck upon a steel cable was heard through the cable in 0.2 seconds and through the air in 3 seconds. The temperature was 0° C.

(*a*) How far from the observer was the blow struck?

(*b*) What was the speed of sound in the cable?

Solution by Paul H. Kerrick, 1916, Riverside (Cal.) High School.

Also solved by Carlton Pardee, 1916, Riverside, Cal., and R. W. Boreman, Parkersburg, W. Va.

Velocity of sound in air at 0° C. is 1,087 ft. per sec.

1,087×3 = 3,261 ft., distance of person from below.

3,261÷0.2 = 16,305 ft. per second, velocity of sound in cable. *Ans.*

226. *From Chemistry, 1915, College Board.*

Find the number of liters of carbon dioxide that will result from the addition of sufficient hydrochloric acid to 100 grams of calcium carbonate [10]. [Atomic weights: C = 12, O = 16, Cl = 35.5, Ca = 40.]

Solution by R. W. Boreman, Parkersburg, W. Va.

$$\underset{100\text{ g.}}{CaCO_3} + 2HCl = CaCl_2 + H_2O + \underset{x}{CO_2}$$

(100 over $CaCO_3$; 44 over CO_2)

100 : 44 = 100 : x. x = 44 g. of CO_2.

1 liter of CO_2 weighs 1.9641 g.

44 divided by 1.9641 = 22.4 liters of CO_2.

227. What do the readers of SCHOOL SCIENCE AND MATHEMATICS wish to see discussed in the *Science Questions* department?

Is the material at present published (1) interesting, (2) instructive, (3) helpful, (4) stimulating? If not, why? How can we know whether it is right unless we hear directly from you? Nothing is more useful than constructive criticism.

Report your experiences and investigations.

Help the Editor of this department by sending to him copies of your June examinations in chemistry, physics, botany, zoology, physical geography and especially general science.

(Further examination lists as above are wanted.)

Comments by Hanor T. Webb, Tennessee State Normal, Memphis, Tenn.

Personally, I would find more interest in concise discussion and criticism of pedagogical principles and practices, than in working examples. (In fact, it was the queries regarding the Des Moines exams. that first stirred me up.) But I have no doubt that to many people such discussion would seem unprofitable.

However, I am not one of those who consider the space allotted to *Science Questions* wasted—I always read them, whether I answer any or not.

I like the idea of publishing college exams. It lets us know what the college men are revolving in their minds, and keeps some of us, who feel that we should yield somewhat to the demand for the applied in science, from wandering too far afield.

Would the following suggestions be in any way practical? Divide *Science Questions* into three parts (appearing simultaneously, or in successive issues):

1. Theoretical (or "The Book").
2. Mathematical (or "The Board").
3. Experimental (or "The Desk").

Have a rule regarding length of questions and answers, and publish the most concise and well worded (as you do now) in solutions of problems.

Examination papers from Dr. Lyman C. Newell, Boston University, Boston, Mass., A. C. Norris, Rockford, Ill., and Hanor A. Webb, Memphis, Tenn., are gratefully acknowledged. Will others please send papers to the Editor of this department?

TEN YEARS OF THE SCHOOL OF APPLIED INDUSTRIES, CARNEGIE INSTITUTE OF TECHNOLOGY.

The Nineteen Hundred and Sixteen commencement marked the close of the first decade of the School of Applied Industries, Carnegie Institute of Technology. Nine thousand seven hundred seventy-two young men were enrolled as students at some time or other during those years, 476 of whom have been awarded diplomas or certificates of graduation for completing the regular courses. Twenty-one different industries have been enriched by reason of the hundreds of young men who have gone into them after pursuing the broad technical training afforded by the school.

When the school of Applied Industries opened its doors in January, 1906, there were no precedents to follow and no traditions to hinder. Industrial education, as interpreted by the Carnegie Institute of Technology, is only ten years old. It is in perfect accord with the prevailing ideas of the leaders in this type of education in this country and abroad. The evolution of the courses and the kind of students attracted are tributes to the wisdom of Andrew Carnegie, the founder, and the organizing genius of Director Hamerschlag and the members of the staff with whom he surrounded himself. Since the very beginning, the school has been in the direct charge of Dean Clifford B. Connelley, one of the pioneer advo-

cates and workers for practical education. His engaging personality has been the inspiration to the thousands of students who have entered the institution. The faculty consists of forty-nine full-time instructors and twenty-five part-time men, each member being chosen from the standpoint of industrial preparation, as well as academic record.

It has been referred to as a trade school. It is not a trade school, except in the sense that instruction is offered in twenty-one different trades. The graduate, after completing his three years of training in the day school, does not enter industrial life as a machinist, a draftsman, an architect, a bricklayer, a carpenter, a sheet metal worker, a plumber, an electrician, as is commonly supposed. It is true that he does hire out to the contractor in the building trades, or in one or the other of the machinery trades, but not as a skilled worker in any special line of work. His training has been of a broader nature, not confining itself to a specialized operation in a single trade nor to the whole of a single trade. It is more concerned with the trades as groups.

The course in printing has a field all its own, and the work is outlined to develop an all-around craftsman, who is both an artisan and an artist.

For a more mature man who, on account of his previous experience in the industries, can profitably take a single trade in which he desires to perfect himself, a ONE-YEAR INTENSIVE TRADE COURSE is offered. No student who has been inexperienced in the trades is permitted to take this work.

The combination of the theoretical and the practical, so closely allied, tends to produce the THINKER in the industry instead of the automaton, or rule-of-thumb worker.

Five years ago, when industrial education first began to assume its importance as a part of public school curriculum, the School of Applied Industries started to train a new type of leader—the teacher of industrial education.

In addition to the day courses, the Night School of Applied Industries is a powerful factor in training workers, especially for the local industries. This is in the nature of a continuation school where the young man works at his trade during the day and comes to school for three nights a week, two hours each night.

An industrial teacher's course is also conducted in connection with the night school. Employers of labor encourage their employees to attend night school, and certain labor organizations require attendance on the part of apprentices. No special requirement for entrance is necessary, except that the applicant be a worker during the day and that the training desired be in line with his chosen occupation.

The total fees for a day course for the school year, from September 14, 1916, to the middle of June, 1917, are $48.00 for a resident of Pittsburg and $58.00 for a nonresident. The fees for a night course from October 2, 1916, to May 1, 1917, are $16.00 for residents, and $18.00 for all others.

After the experience of the ten years, no better indication can be had that the training has been in the right direction than the willing cooperation of the various manufacturers, employers and trade organizations as evidenced by their readiness to take the graduates into their employ and the help given in working out the courses. In fact, sufficient evidence is already at hand to show that the School of Applied Industries is meeting the demand that has been established for industrial training to be of the right sort.

MICHIGAN COPPER A RECORD BREAKER.

The complete reports from Michigan copper mines received by the United States Geological Survey show the production to be the largest in the history of the industry. The total refined copper produced amounted to 238,956,410 pounds according to B. S. Butler, as compared with 158,009,748 pounds in 1914 and with 231,112,228 pounds in 1912, the record production previous to 1915.

At an average price of 17.5 cents per pound, the copper output of Michigan had a value of about $41,800,000 for 1915.

The copper mines produced 585,933 ounces of silver in 1915, valued at $297,068.

There were mined and milled in the Lake Superior district 12,334,699 tons of ore-producing concentrates containing 265,283,378 pounds of copper, or a recovery of slightly above one per cent of copper from the ore. A portion of the concentrates produced was not smelted in 1915.

A METHOD OF COMPUTING SQUARE ROOT.

By Mrs. M. W. Arleigh,
San Francisco, Cal.

Two years ago while studying a table of squares, I saw that the difference of the squares of any two successive integers is equal to the sum of the integers. This property struck me with peculiar force, though I may have seen it before, and I determined to find, if possible, a simple way of using it to compute square root. The method finally worked out is based on the following:

Let x and y be any numbers.

$$x^2-y^2=(x-y)\ (x+y).$$
$$x^2=y^2+(x-y)\ (x+y).$$

When $x-y=1$, $x^2=y^2+1\ (x+y)$.
When $x-y=2$, $x^2=y^2+2\ (x+y)$.
When $x-y=.1$, $x^2=y^2+.1\ (x+y)$, and so on.

An example will show the method.

Complete the square root of 5317.

$$\begin{aligned}
70^2 &= 4900\\
70+71 &= 141\\
71^2 &= 5041\\
72+71 &= 143\\
72^2 &= 5184\\
73+72 &= 145\\
73^2 &= 5329\\
.1\ (73.1+73) &= 14.61\\
73.1^2 &= 5343.61\\
&\ \ 2.9244\\
73.12^2 &= 5346.5344
\end{aligned}$$

As the amount to be added can usually be found mentally, it need not be indicated on paper. After some practice, many additions may be avoided by inspection. Thus, in this example one could go from 70^2 to 73^2 by adding $3\ (70+73)$.

I find that children learn this method readily by writing out a table of squares and seeing that $2^2-1^2=2+1$, $3^2-2^2=3+2$, $4^2-3^2=4+3$, and so on.

ARTICLES IN CURRENT PERIODICALS.

American Forestry, for September; *Washington, D. C.; $3.00 per year, 25 cents a copy:* "Shortleaf Pine—Identification and Characteristics" (six ill.), Samuel B. Detwiler; "Commercial Uses of Shortleaf Pine" (six ill.); "Canada's Deadly Forest Fires (five ill.), Robson Black; "The Cause of the Fire—and Future Prevention" (three ill.), Clyde Leavitt; "Mount Rainier National Park" (nine ill.), Mark Daniels; "The Bird Department—Autumn Birds and Their Message—The Larks" (eight ill.), A. A. Allen; "The Appalachian Forest Purchases," John W. Weeks; "Ornamental and Shade Trees—Selecting Trees for Planting" (four ill.), J. J. Levison.

Condor, for September-October; *Hollywood, Los Angeles, Cal.; $1.50 per year, 30 cents a copy:* "More Bird Notes from Big Bear Valley, San Bernardino Mountains" (with five photos), Wright M. Pierce; "Meeting Spring Half Way—II," Florence Merriam Bailey; "A Hospital for Wild Birds" (with two photos), Dr. W. W. Arnold; "Some Birds of the Fresno District, California; Supplementary Notes," John G. Tyler; "Some Bird Notes from Humboldt Bay," Joseph Mailliard.

Geographical Review, for September; *Broadway, at 156th Street, New York City; $5.00 per year, 50 cents a copy:* "The Water Barriers of New York City" (one map, one photo), Ellsworth Huntington; "Some Geographic Problems Incident to the Growth of New York City" (twelve maps, nine diagrs., six photos), E. P. Goodrich; "The Population of New York State" (five maps, four diagrs.), Albert Perry Brigham; "Recent Changes in Bogoslof Volcano" (one map, one diagr.), Sidney Powers; "Geographical Record."

Journal of Geography, for October; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Practical Exercises on Topographic Maps," W. M. Davis; Development of Agriculture in the Pine Barrens of the Southeastern United States," Roland M. Harper; "A Plea for Better Questions," Robert M. Brown; "The Aims and the Work of the National Council of Geography Teachers," The Editor; "The Salt Mines of Austria," Emily A. Budd; "The Australian Barrier Reef," C. E. Granger; "An Experiment in Correlation," V. C. Bell.

Nature-Study Review for September; *Ithaca, N. Y.; $1.00 per year:* "When the Birds Nested," L. H. Bailey; "An Attractive Flower Book," C. C. Leeson; "Nature Study in Rhode Island," W. G. Vinal; "The Copperhead Snake," G. T. K. Norton; "Elementary Physical Science," Jos. B. Shine; "September Nature-Study," Anna B. Comstock.

Physical Review for September; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "The Relations of the Photo-Potentials Assumed by Different Metals when Stimulated by Light of a Given Frequency," A. E. Hennings and W. H. Kadesch; "The Value of *h* Determined Photo-electrically from the Ordinary Metals," W. H. Kadesch and A. E. Hennings; "The Theory of the Cathode Fall of Potential," H. A. Wilson; "The Influence of Occluded Gases on the Photo-electric Effect," Robert James Piersol; "Note on the Parson Electrometer," G. E. M. Jauncey and G. J. Buchner; "The Black Body at the Melting Point of Platinum as a Fixed Point in Photometry," Herbert E. Ives; "The Radiant Luminous Efficiency of the Carbon Incandescent Lamp and the Mechanical Equivalent of Light," Herbert E. Ives and E. F. Kingsbury; "Change of Resistance with Temperature of Various Sodium Amalgams," Ralph C. Rodgers; "The Luminosity of the Positive Column in Gases at Low Pressures," H. A. Wilson; "Determination of the Laws Relating Ionization Pressure to the Current in the Corona of Constant Potentials," Earle H. Warner; "On the Influences Contributing to the Variation of Contact Electromotive Force with Time," Otto Stuhlmann, Jr.; "The Normal Photo-electric Effect of Lithium, Sodium and Potassium as a Function of Wave-Length and Incident Energy," Wilmer H. Souder; "Some Remarks on the Mica X-Ray Spectrometer of W. S. Gorton," Manne Seigbahn; "Note on Black-Body Brightness Equation Based on Equivalent Wave-Lengths," Herbert E. Ives and E. F. Kingsbury.

Popular Astronomy, for October; *Northfield, Minn.*; *$3.50 per year, 35 cents a copy:* "The Semicentennial of the Dearborn Observatory," Philip Fox; "Address by Professor Elias Colbert;" "Address by Professor E. E. Barnard;" "The History of the Discovery of the Solar Spots—Continued," Walter M. Mitchell; "Fox's Measures of Double Stars," Eric Doolittle; "A Small Star with Large Proper Motion" (with Plates XXIX and XXX), E. E. Barnard; "Invisible Comets," William H. Pickering; "Moonscapes" (with Plates XXXI-XXXIV), Russell W. Porter.

School Review, for September; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "The Sketch Map as an Aid in the Teaching of Historical Geography," Curtis H. Walker; "Directed Teaching and Directed Observation—A Correction and an Explanation," J. D. Deihl; "The Woolley Tests Applied to a Prevocational Class of Boys," Warren W. Coxe; "Correlation between Amounts of Home Study and Class Marks," W. H. Heck.

CLASSROOM SAYINGS.

News-letter from New York, quoted in *Boston Herald*, says: "The thermometer and the hydrometer moved upward together, the former registering 85."

Pupils are not the only ones who make comical blunders.

"Reflection of light is the bending of an object."

"An image is a space cast on a screen that is shut off by the light."

"An image is a part of a shadow."

"Light is reflected when it strikes anything solid like water."

"Ananias was the greatest Roman dramatist."

"The temperature range is greatest in London because the Meridians and Equator meet there."

"Lake Chicago was a terminal moraine gouged out by the North American glacier."

"Lake Chicago was a lake containing sand and gravel."

"We have summer in June because June is one of the hottest months and because the year is divided into four parts—summer, winter, autum and spring."

"The states bordering on the Mississippi river are Minnesota, Wisconsin, Iowa, Indiana, Ohio, Chicago, Tennessee and Pennsylvania."

"The Soo canal is up in Pennsylvania. The Erie canal is up near Hudson Bay. The Calumet Sag canal is up in Joliet."

"The Chicago river is making a delta."

"The Erie canal connects Lake Superior and Lake Erie."

"The Antic Arctic circle is the boundary of the South Fidgets zone."

"The Salmon come up our streams to spoon."

Merchant: "I'm not a Catholic but I've a picture of the Pope in my den."

Customer: "Benedict?"

Merchant: "No, the old one—Plus X."

What is centrifugal force?

Centrifugal force is the force with which the ends of a circle attempt to go to the center when rotated.

What furnishes power in a gas engine?

1. Gas in spark and gas explodes the spark.
2. Time exposure of gas mixtures furnish power in a gas engine.

Explaining a freeing mixture: Salt melts the ice and takes the cold out of the ice.

Focal length of a lens is the point at which the distance between the distant object and the lens is brought to a focus.

GREATEST WORLD PETROLEUM OUTPUT.

That 1915 was the most successful year of production in the history of the petroleum industry is shown by statistics just compiled under the supervision of J. D. Northrop of the U. S. Geological Survey, Department of the Interior.

The distribution of this production is shown in the following table:

WORLD'S PRODUCTION OF CRUDE PETROLEUM IN 1915 AND TOTAL YIELD SINCE 1857.

Country	Quantity, 1915		Quantity, 1857-1915	
	Barrels of 42 gallons	Metric tons	Barrels of 42 gallons	Metric tons.
United States	[1]281,104,104	37,480,547	[1]3,616,561,244	482,208,266
Russia	68,548,062	9,353,077	1,690,781,907	222,984,256
Mexico	32,910,508	4,388,068	123,270,377	16,420,008
Dutch East Indies	12,386,808	1,710,445	148,999,921	20,087,939
Roumania	12,029,913	1,673,145	130,012,387	17,477,878
India	[2]7,400,000	986,667	80,789,711	10,771,961
Galicia	4,158,899	578,388	136,032,500	18,918,364
Japan and Formosa	3,118,464	415,785	30,169,622	4,022,606
Peru	2,487,251	331,633	16,794,223	2,239,229
Germany	995,764	[2]140,000	13,961,333	1,875,974
Trinidad	[2]750,000	100,000	2,819,430	375,924
Argentina	516,120	75,900	1,033,121	151,693
Egypt	221,768	29,569	1,308,496	174,466
Canada	215,464	28,729	23,709,074	3,161,210
Italy	39,548	[2]5,500	842,020	119,279
Other	[2]10,000	1,333	372,000	49,600
	426,892,673	57,298,786	6,017,457,366	801,038,653

[1]Marketed production. [2]Estimated.

MORALITY CODE FOR CHILDREN.

The National Institute for Moral Instruction of Washington, D. C., has control of a competition for the best children's code of morals, to be submitted by seventy code writers who have been selected, one from each state in the Union, and from the more populous states two or more. A prize of $5,000 has been offered by an American business man for the best code. The editor of this Journal has been selected as one of the writers from the state of Illinois. Although he has some conception concerning the nature of this morality code and what should be done in the proper moral training of children in the teen age, he is asking the readers of this Journal, for the good of this cause, to submit to him at as early a date as is convenient, their ideas concerning the proper moral ideas to be taught to our youth. These suggestions he will use in the preparation of the code. Any assistance that the readers submit will be greatly appreciated.

PLASTIC FLOW.

There is a property of certain forms of matter, such as the clay used in making pottery, which has long been regarded as of great importance, but which has never been understood. This property, known as plasticity or the capacity of a material for being molded into a desired shape and then retaining it, has been made a subject of study by the Bureau of Standards, Department of Commerce, and the results of the study have just been published in *Scientific Paper, No. 278.*

Forcing mixtures of clay and water through tubes of small diameter, the rates of flow at different pressures were measured. The experiments showed that, in a plastic substance, a considerable force is required to start the flow or to overcome the friction between the particles of solid. This friction in plastic flow enables one easily to distinguish between a plastic substance and a true fluid, even though the fluid may be very viscous like pitch. It was found that the plasticity of a material depends principally upon the fineness of the solid particles. It can be measured by the force required to overcome the friction, and by the rate of flow after the friction is overcome, this later quantity being known as the "mobility."

Copies of the paper will be sent free to persons interested upon application to the Bureau of Standards, Washington, D. C.

STUDY OF THE VOLATILIZATION OF PLATINUM.

The Bureau of Standards, Department of Commerce, has just issued *Scientific Paper, No. 280,* in which are given the results of an investigation, made at the suggestion of a committee of the American Chemical Society, on the loss in weight on heating of platinum crucibles of various makes and degrees of purity. The results obtained should prove of considerable value to the analytical chemist in aiding him to eliminate a troublesome source of error. It is shown that all grades of platinum contain at least traces of iron, that there is no appreciable loss in weight of crucibles heated to 900° C., that above this temperature, the loss increases very rapidly with temperature and is greatest for platinum containing iridium and least for platinum alloyed with rhodium.

Copies of the paper, which is entitled *Further Experiments on the Volatilization of Platinum,* may be obtained free upon application to the Bureau of Standards, Washington, D. C.

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PRODUCTION OF PHOSPHATE ROCK IN 1915.

The phosphate rock sold in the United States in 1915, as shown by figures compiled by the United States Geological Survey, amounted to 1,835,667 long tons, valued at $5,413,449. This is a decrease of 898,376 long tons in quantity and of 4,194,592 in value, according to W. C. Phalen, of the Survey, as compared with the production of 1914, which, in turn, showed a marked decrease compared with that of 1913. The output came, as usual, principally from Florida, Tennessee, and South Carolina, but there was a small output from Arkansas, Idaho, Utah, and Wyoming.

The quantity of phosphate rock marketed in Florida in 1915, including hard rock and land pebble, was only 1,358,611 long tons, valued at $3,762,239. Compared with 1914, this was a decrease of 780,280 long tons in quantity and of $3,592,505 in value. The hard-rock industry, especially, is in a badly crippled condition owing to the war in Europe.

The production of phosphate rock in Tennessee, together with a very small production in Arkansas, in 1915 was 389,759 long tons, valued at $1,327,747. Compared with 1914, this was a decrease of 93,444 long tons in quantity and $495,023 in value.

The production of phosphate rock in South Carolina in 1915, which was 83,460 long tons, valued at $310.850, also greatly decreased, as compared with that of 1914. The production in Idaho, Utah and Wyoming in 1915 was 3,837 long tons, valued at $12,613.

Conditions in the phosphate-rock industry during 1915, especially in Florida, were about the same as they were at the end of 1914.

Soon after the outbreak of the European war, the phosphate-mining companies of Florida—not only the companies that produce the high-grade rock for export but also those that supply the domestic trade—either curtailed production very materially or suspended mining. The

companies engaged in a combined export and domestic trade or in domestic trade alone were less seriously affected than those doing an exclusive export business.

Shipments of phosphate rock to Germany, which hitherto has been a large consumer, have of course almost entirely ceased, and those to the other European countries have been seriously interrupted.

The great demand for sulphuric acid, especially toward the end of 1915, has also curtailed the production of phosphate rock. The prices of sulphuric acid have been so high that the manufacture of acid phosphate has been somewhat reduced and the reduction has caused a decline in the market for phosphate rock.

BOOKS RECEIVED.

Arithmetic for Engineers, by Charles B. Clapham, University of London. Pages xi+436. 15x22 cm. Cloth. 1916. Chapman & Hall, London, England.

Plane Geometry, by Fletcher Durell, Lawrenceville School, and E. E. Arnold, University of the State of New York. 300 pages. 13x19 cm. Cloth. 1916. Charles E. Merrill Company, New York City.

Plane and Solid Geometry, by William Betz, East High School, Rochester, and Harrison E. Webb, Manual Training High School, Newark, N. J. Pages xi+507. 13x19 cm. Cloth. 1916. $1.36. Ginn & Company, Boston.

Industrial Arithmetic, by Nelson L. Roray, Dickinson High School, Jersey City. Pages viii+154. 13x19 cm. Cloth. 1916. 75c net. P. Blakiston's Son & Company, Philadelphia.

Modern Business Arithmetic, by Harry A. Finney, Walton School of Commerce, Chicago, and Joseph C. Brown, University of Illinois. Pages xv+298. 15x21 cm. Cloth. 1916. Henry Holt & Company, New York City.

First-Year Mathematics, by George W. Evans, Charlestown High School, Boston, and John A. Marsh, English High School, Boston. 253 pages. 13x19 cm. Cloth. 1916. 90 cents. Charles E. Merrill Company, New York City.

Trigonometric and Logarithmic Tables, by George Wentworth and David E. Smith. Pages v+104. 15x24 cm. Cloth. 1916. 60c. Ginn & Company, Boston.

Outline and Suggestive Methods and Devices on the Teaching of Elementary Arithmetic, by Franklin P. Hamm, Camden, N. J. Pages v+40. 13x18 cm. Paper. 1916. J. B. Lippincott Company, Philadelphia.

Laboratory Manual of Inorganic Chemistry for Colleges, by Lyman C. Newell, Boston University. Pages vi+240. 13.5x19 cm. Cloth. 1916. 60c. D. C. Heath & Company, Chicago.

Human Physiology, by Percy G. Stiles, Harvard University. 405 pages. 14x21 cm. Cloth. 1916. $1.50 net. W. B. Saunders Company, Philadelphia.

First Course in General Science, by Frederic D. Barber, Illinois State Normal University. Merton L. Fuller, Bradley Polytechnic Institute, John L. Prices and Howard W. Adams, Illinois State Normal University. Pages vi+607, 13x19 cm. Cloth. 1916. $1.25. Henry Holt & Company, New York City.

Annual Report of the Board of Regents of the Smithsonian Institution for 1915. Pages xii+544. 15x23.5 cm. Government Printing Office.

Pyrex Laboratory Glassware

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Descriptive Price List Upon Request

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NEW YORK CITY and PITTSBURGH, PA.

Book of Thrift, by T. D. MacGregor. Pages xi+349. Cloth. 1916. Funk & Wagnalls Company, New York City.

Essentials of Geography, by Albert P. Brigham, Colgate University, and Charles T. McFarlane, Teachers College, New York. First Book, pages vi+266. 21x26 cm. Cloth. 1916. 72c. Second Book, pages vi+426. 21x26 cm. Cloth. 1916. $1.24. American Book Company, Chicago.

Carnegie Foundation for the Advancement of Teaching. Tenth Annual Report of the President and Treasurer. 141 pages. 18.5x25 cm. Paper. 1915. Also a comprehensive Plan of Insurance and Annuities for College Teachers, by Henry S. Pritchett, President of the Carnegie Foundation. 67 pages. 18.5x25 cm. Paper. 1916. 576 Fifth Ave., New York City.

Descriptive Catalog, D. C. Heath & Company, Publishers. Pages vi+301. 13x18.5 cm. Paper. 1916. D. C. Heath & Company, Boston.

Bulletin of the University of South Carolina. Catalog. 167 pages. 15x23 cm. Paper. 1916. The University, Columbia.

United States Official Postal Guide. 742 pages. 16.5x24 cm. Paper. July, 1916. Post Office Department, Washington.

Agricultural Arithmetic, by W. T. Stratton and B. L. Remick, Kansas State Agricultural College. Pages x+239. 13x19 cm. Cloth. 1916. 50c. The Macmillan Company, New York City.

Elementary Algebra, by Florian Cajori, Colorado College, and Letitia R. Odell, North Side High School, Denver. Pages ix+201. 13x19 cm. Cloth. 1916. 75c. The Macmillan Company, New York City.

A Textbook of Physics, edited by A. Wilmer Duff. Fourth edition. Pages xiv+692. 14x21 cm. Cloth. 1916. $2.75. P. Blakiston's Son & Company, Philadelphia.

Second-Year Mathematics, by Ernst R. Breslich, University High School, University of Chicago. Pages xx+348. 13x20 cm. Cloth. 1916. $1.00 net. The University of Chicago Press.

A Textbook of Human Physiology, by Albert P. Brubaker, Jefferson Medical School. Pages xii+776. 16x24 cm. Cloth. 1916. $3.00 net. P. Blakiston's Son & Company, Philadelphia.

BOOK REVIEWS.

Hospital Laboratory Methods for Students, Technicians and Clinicians, by Frank A. McJunkin, Marquette University School of Medicine, Milwaukee. Pages xi+139. 13.5x20 cm. Cloth. 1916. $1.25 net. P. Blakiston's Son & Company, Philadelphia.

A very timely book—just the handbook that the laboratory worker needs. It contains directions for handling material for examination, both before and after it reaches the laboratory. The book is valuable, too, as there are no directions given which have not been found to work. There are ninety-four figures, most of which were especially made for this work. Major paragraphs begin with boldfaced type. It is well indexed, there being seven pages of double column matter here. It is one of the best books of the kind in print. C. H. S.

Social Problems, by Ezra T. Towne, Carleton College. Pages xviii+406. 13.5x19 cm. Cloth. 1916. $1.00. The Macmillan Company, New York City.

A veritable hand book of material bearing on social problems, correlated and arranged so that it may be used as a basis for classroom work. Very little of the theory is present, but the body of the book fairly bristles with the practical side of the question. It is written in clear and understandable language, thus making the book at once interesting, not only to the student but layman as well. A close study of the book, and a carrying out of its recommendations by the reader as far as possible, will give one a better and clearer understanding of his own times. There are seventeen chapters, each one closing with a list of pertinent questions bearing on the matter discussed in the chapter. There is also a splendid list of references together with suggestions for supplemental reading. Each chapter is prefaced with an outline of the material presented therein. Major paragraphs begin with bold-faced type, supplementary paragraphs in italics. Many suggestive half tones are scattered throughout the book. There are several pages of supplementary questions appended. There is a complete double-column index at the end. Mechanically, the book is well made. It deserves a wide circulation. C. H. S.

Sex-Education, by Maurice A. Bigelow, Teachers College, Columbia University. Pages xi+251. 13x19 cm. Cloth. 1915. $1.25. The Macmillan Company, New York City.

Of the many books bearing upon this subject which have recently come from the press, there are few equals and no superiors. The author presents the matter from a biologist's viewpoint, which, of course, is one of the best. He has made a thorough study of the question from all angles, and has evolved a book which all parents and teachers attempting to instruct in this phase of life problems ought to study. Will all who read these brief statements get and read the book, advertising it to their friends? C. H. S.

Community Arithmetic, by Brenelle Hunt, Normal School, Bridgewater, Mass. Pages viii+277. 14x19 cm. 1916. American Book Company, New York City.

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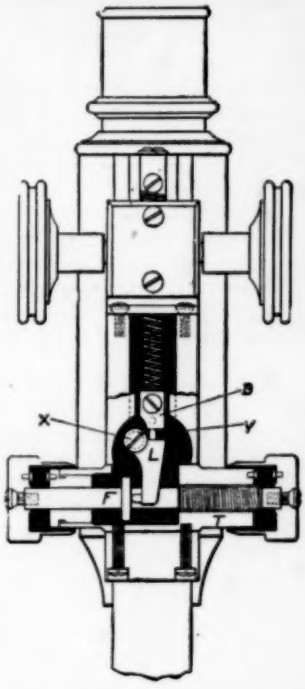

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To provide suitable applications for the processes of arithmetic those that will give the pupil a clear understanding of the arithmetic of industrial and business activities, is the purpose of this book. The work is based on lesson stubjects, such as: Making change; problems of the grocery, construction, dry goods, meat market, poultry, railroad freight, carpentry, coal business, hardware, household expenses, taxes, insurance, and saving and investing money. The problems seem to be well adapted to the purpose. The many pictures and tables dealing with things that already function in the lives of the pupil, together with the problem material, should make this book of real value to the pupils in the upper grades of the elementary schools or in the junior high school.

H. E. C.

Laboratory Lessons in General Science, by Herbert Brownell, Teachers College, University of Nebraska, Lincoln, Neb. Pages xv—215. 13.5x19.5 cm. Cloth. 1916. 80c. The Macmillan Company, New York City.

Almost without an exception, every author of a general science course up to this time has published his textbook first, and has given the high school teachers a full year in which to become fixed in the textbook method of teaching the subject, before bringing out a manual to stress the fact that general science is a laboratory science. Professor Brownell's first book on this subject is *Laboratory Lessons in General Science.* He contemplates the publication of a textbook in general science at some later time, but that, from his point of view, is of lesser importance.

This book is unique in that it draws upon the pupils experiences as well as upon the laboratory and the library for the materials needed in meeting its requirements. In doing this, questions call for facts that the pupils have gleaned from life. Directions help the pupils to turn to the laboratory for the assistance it may give, and specific references enable the student to use the library readily and without an undue waste of time in securing its contribution. This is certainly an ideal teaching procedure, and in this manual this procedure is brought down to the plane of practical schoolroom working conditions.

The author has made bold to take a step which no other author has, as yet, taken. He places the social upon the same plane with the natural sciences, and stresses that phase of every topic throughout the manual. In fact, the treatment of no topic, whether it be the human body, water, the atmosphere, the weather, the household. industries, work and machines, electricity, or some phase of astronomy, is considered complete until it has been made to function in the social life of the student. This alone should challenge the attention of teachers having the modern point of view.

Another characteristic, which appeals to all who regard the public schools as responsible for the moral training of the pupils, is the frequent reference, in its directions to the value of right conduct in the life of the individual student. Such a chapter as that on "General Science and Right Living," and many incidental appeals tending to lead pupils to act wisely when a moral crisis comes, are very gratifying.

The book has an exceedingly usable appendix containing a list of the apparatus needed for the course, a collection of reference books for the library, a list of government bulletins needed, and very complete specific references for class assignments. Considered from many angles, it promises to be one of the successful manuals for this subject. It will, as well, be a storehouse of suggestive material for grammar grade teachers who have elementary science to teach.

B. C. H.

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The Central Association

The Central Association of Science and Mathematics Teachers will hold its annual meeting at the University of Chicago on

DECEMBER 1 and 2, 1916

The most noteworthy feature of the meeting this year is the number of speakers of talent and position that have been secured for the various programs. Those in charge of preparing the programs have made special efforts in this particular and have succeeded remarkably well. At the general program the educational address on "The High School of Tomorrow" will be given by Dr. David Snedden, Professor of Educational Sociology of Columbia University. Professor Snedden is widely known by his addresses. No one is better qualified than he in experience and foresight to speak upon the above subject. He was Commissioner of Education for the State of Massachusetts up to July of this year.

The Panama Canal is easily man's greatest achievement. For about a year many reports have been current about its serviceability because of the landslides. President Wilson requested the National Academy of Science to appoint a committee of experts to study the possibility of controlling the landslides. The committee was appointed in November, 1915, and at the present time its work is practically finished. The Association has been able to secure an eminent member of this committee, John F. Hayford, Director of the College of Engineering, Northwestern University, to address the meeting, giving the facts about the landslides at Panama. The lecture will be illustrated by stereoptican, using the official photographs.

The section programs, Agriculture, Biology, Chemistry, Earth Science, Home Economics, Mathematics and Physics, are particularly strong in having speakers of unusual merit. Never before has the Association better promise of a successful meeting to offer its members. The Physics Section will hold joint sessions with the American Physical Society, and on Saturday morning the Earth Science Section will have a joint session with the Illinois State Council of Geography Teachers. Programs will be issued about November 15.

The Association is making progress. Each succeeding year membership in it becomes more valuable and more necessary for ambitious teachers. A total of 223 new members were received during 1915. On October 1, 220 applications for membership had been received for 1916, and they are coming in more rapidly every day. Starting with less than a hundred members in 1903, the Association will have well over a thousand members by the time of the next meeting. "Watch the Central Association Grow!" and help it grow by bringing a new member to the next meeting.